

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization International Bureau



(43) International Publication Date
23 October 2003 (23.10.2003)

PCT

(10) International Publication Number
WO 2003/088316 A3

(51) International Patent Classification⁷: C25D 5/00, 5/48,
5/52, 5/50, 5/08, B23H 11/00, 3/00, 5/00, 7/00, 9/00

(74) Agents: YIM, Peter, J. et al.; Morrison & Foerster LLP,
425 Market Street, San Francisco, CA 94105-2482 (US).

(21) International Application Number:
PCT/US2003/011417

(81) Designated States (national): AE, AG, AL, AM, AT, AU,
AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU,
CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH,
GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC,
LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW,
MX, MZ, NI, NO, NZ, OM, PI, PL, PT, RO, RU, SC, SD,
SE, SG, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US,
UZ, VC, VN, YU, ZA, ZM, ZW.

(22) International Filing Date: 11 April 2003 (11.04.2003)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/372,263 12 April 2002 (12.04.2002) US
60/382,133 21 May 2002 (21.05.2002) US
60/387,826 8 June 2002 (08.06.2002) US
60/398,316 24 July 2002 (24.07.2002) US

(71) Applicant (for all designated States except US): ACM RESEARCH, INC. [US/US]; Suite 610, 46520 Fremont Boulevard, Fremont, CA 94538 (US).

(72) Inventors; and

(75) Inventors/Applicants (for US only): WANG, Hui [US/US]; 340 Jacaranda Drive, Fremont, CA 94539 (US). WANG, Jian [CN/US]; 39960 E. Las Paemas Court, Fremont, CA 94539 (US). YIH, Peihaur [CN/US]; 8 Alpine Road, Boonton, NJ 07005 (US). WU, Huiquan [CN/US]; 12209 Village Square Terrace Apt.202, Rockville, MD 20852 (US).

(84) Designated States (regional): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— with international search report

(88) Date of publication of the international search report:
31 December 2003

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

WO 2003/088316 A3

(54) Title: ELECTROPOLISHING AND ELECTROPLATING METHODS

(57) Abstract: In one aspect of the present invention, an exemplary method is provided for electroplating a conductive film on a wafer. The method includes electroplating a metal film on a semiconductor structure having recessed regions and non-recessed region within a first current density range before the metal layer is planar above recessed regions of a first density, and electroplating within a second current density range after the metal layer is planar above the recessed regions. The second current density range is greater than the first current density range. In one example, the method further includes electroplating in the second current density range until the metal layer is planar above recessed regions of a second density, the second density being greater than the first density, and electroplating within a third current density range thereafter.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US03/11417

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : C25D 5/00, 5/48, 5/52, 5/50, 5/08; B23H 11/00, 3/00, 5/00, 7/00, 9/00
 US CL : 205/96, 640, 644, 220, 223, 224, 133

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
 U.S. : 205/96, 640, 644, 220, 223, 224, 133

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
 EAST

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6,162,344 A (REID et al) 19 December 2000 (19.12.2000), col. 2 and claims 3, 4, and 5.	1-20
X	US 6,261,963 B1 (ZHAO et al) 17 July 2001 (17.07.2001), cols. 6 and 7.	21-37, 51-66
---		-----
A		67-78
X,P	US 2003/0038038 A1 (BASOL et al) 27 February 2003 (27.02.2003), pagagraph 0025.	38-50
---		-----
A,P		51-78
X	US 2002/0000271 A1 (RITZDORF et al) 3 January 2002 (03.01.2002), paragraphs 0001 to 0077.	38-66
---		-----
A		67-78

 Further documents are listed in the continuation of Box C. See patent family annex.

* Special categories of cited documents:	
"A"	document defining the general state of the art which is not considered to be of particular relevance
"E"	earlier application or patent published on or after the international filing date
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O"	document referring to an oral disclosure, use, exhibition or other means
"P"	document published prior to the international filing date but later than the priority date claimed
"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&"	document member of the same patent family

Date of the actual completion of the international search

24 September 2003 (24.09.2003)

Date of mailing of the international search report

09 OCT 2003

Name and mailing address of the ISA/US

Mail Stop PCT, Attn: ISA/US
 Commissioner for Patents
 P.O. Box 1450
 Alexandria, Virginia 22313-1450

Facsimile No. (703)305-3230

Authorized officer

Wesley A. Nicolas

Telephone No. (703) 308-1193

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US03/11417

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : C2SD 5/00, 5/48, 5/52, 5/50, 5/08; B23H 11/00, 3/00, 5/00, 7/00, 9/00
US CL : 205/96, 640, 644, 220, 223, 224, 133

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 205/96, 640, 644, 220, 223, 224, 133

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EAST

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6,162,344 A (REID et al) 19 December 2000 (19.12.2000), col. 2 and claims 3, 4, and 5.	1-20
X	US 6,261,963 B1 (ZHAO et al) 17 July 2001 (17.07.2001), cols. 6 and 7.	21-37, 51-66
—		67-78
X,P	US 2003/0038038 A1 (BASOL et al) 27 February 2003 (27.02.2003), paragraph 0025.	38-50
—		51-78
X	US 2002/0000271 A1 (RITZDORF et al) 3 January 2002 (03.01.2002), paragraphs 0001 to 0077.	38-66
—		67-78

<input type="checkbox"/>	Further documents are listed in the continuation of Box C.	<input type="checkbox"/>	See patent family annex.
*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier application or patent published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Z"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		
Date of the actual completion of the international search	Date of mailing of the international search report	09 OCT 2003	
24 September 2003 (24.09.2003)			
Name and mailing address of the ISA/US Mail Stop PCT, Attn ISA/US Commissioner for Patents P.O. Box 1450 Alexandria, Virginia 22313-1450 Facsimile No. (703)305-3230	Authorized officer <i>Wesley A. Nicolas</i> Wesley A. Nicolas Telephone No. (703) 308-1193		

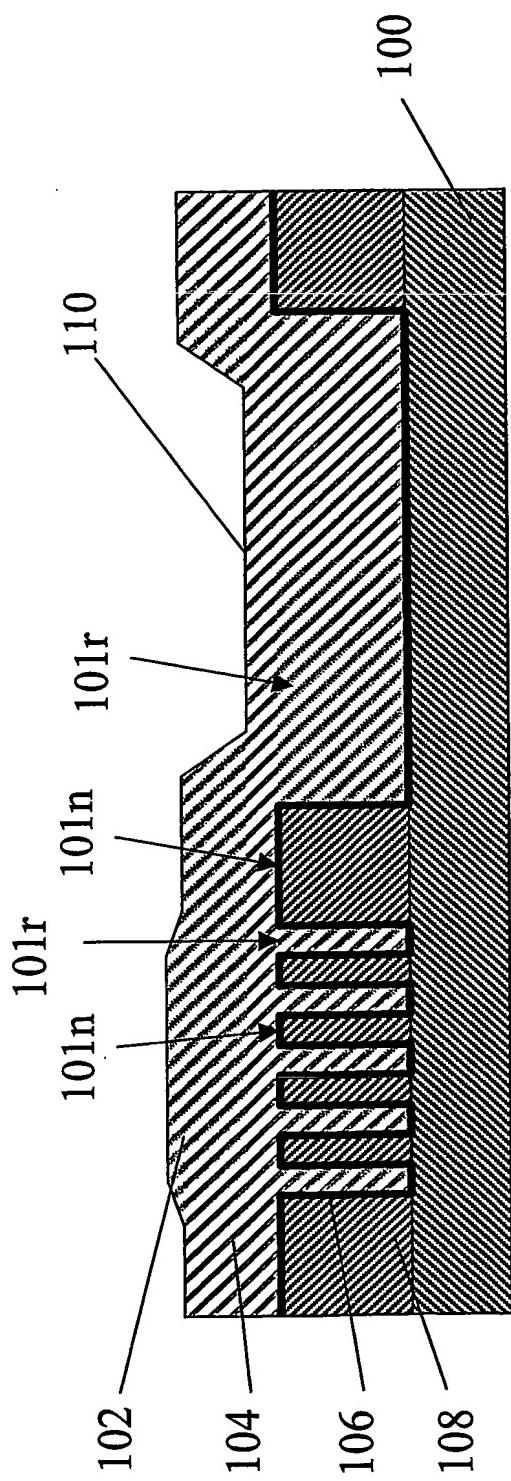


Fig. 1A

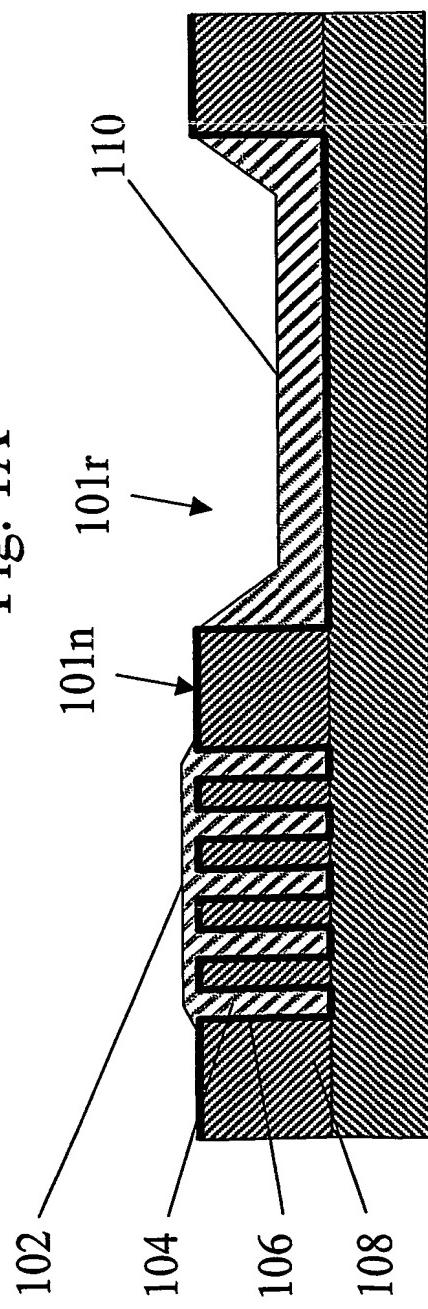


Fig. 1B

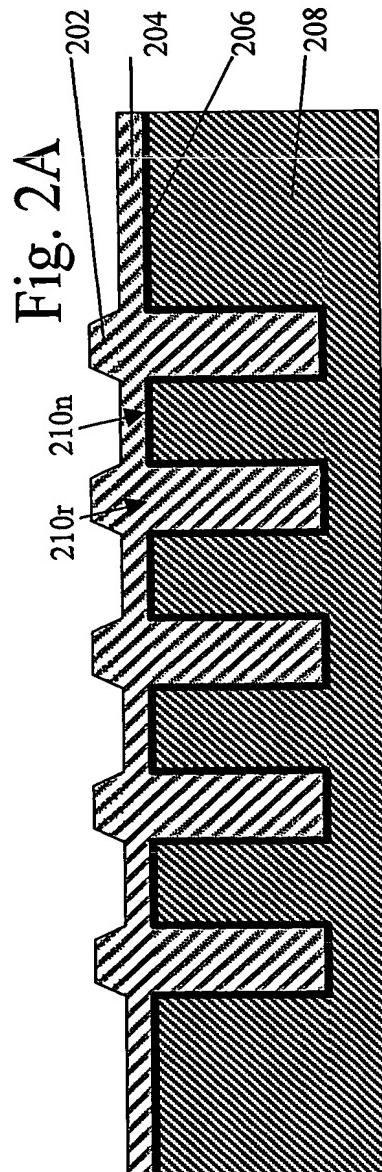
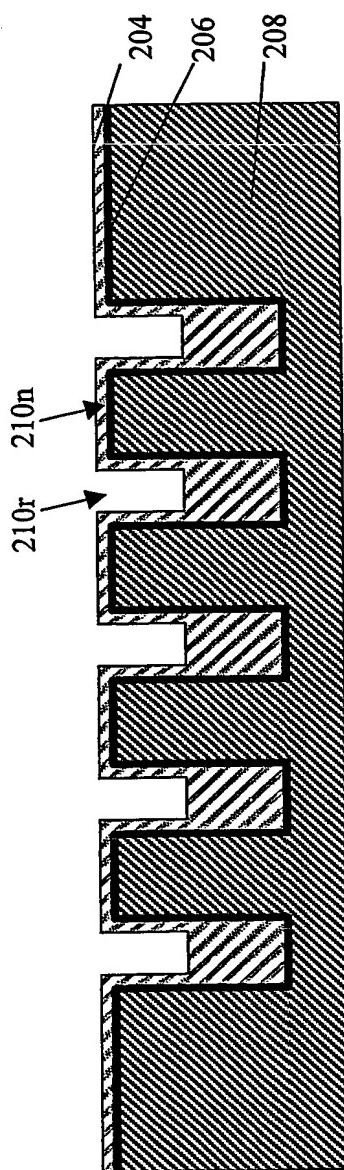


Fig. 2A

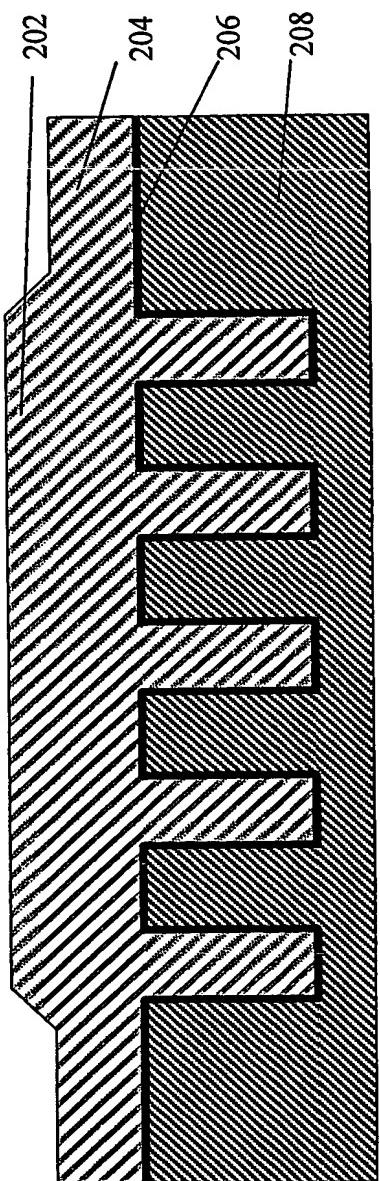


Fig. 2B

Fig. 2C

Plating Time

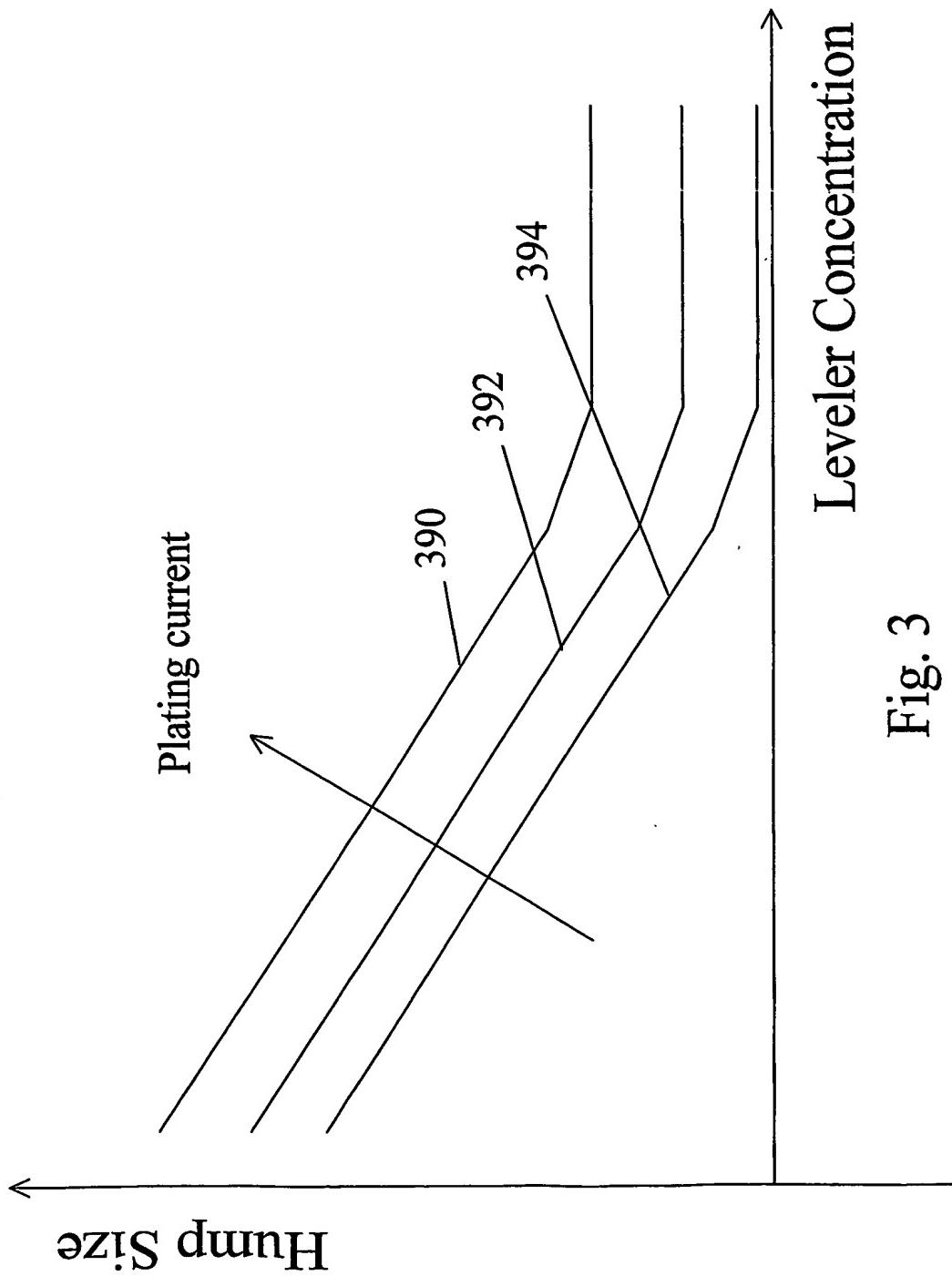


Fig. 3

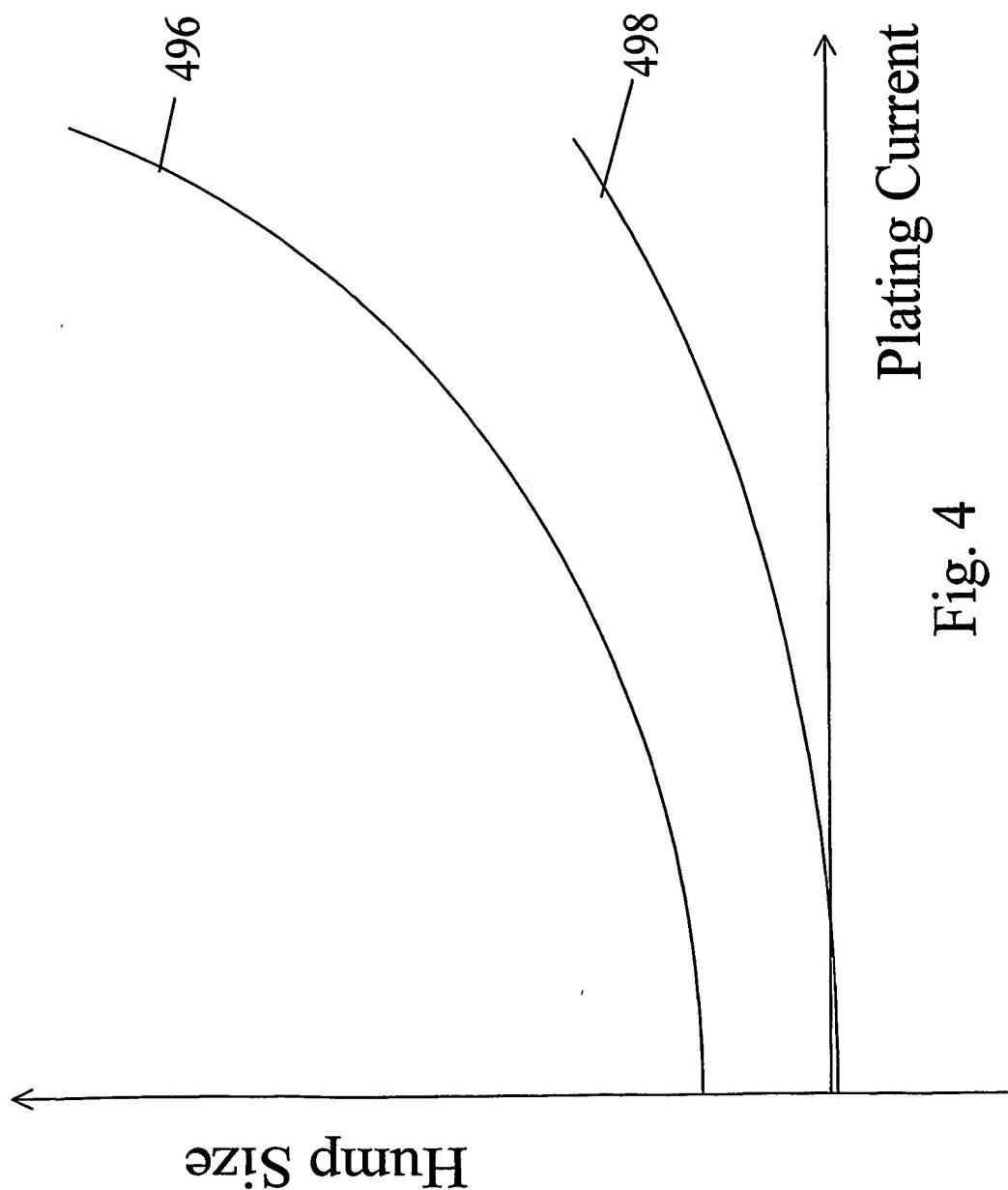
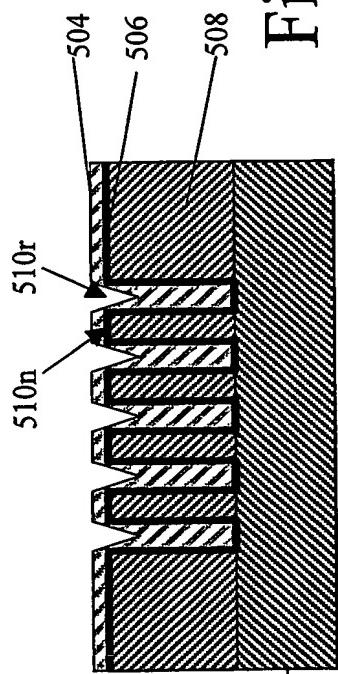
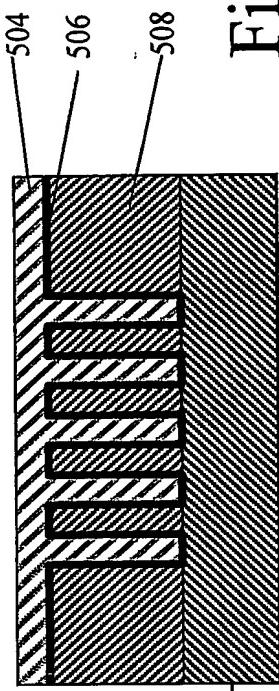
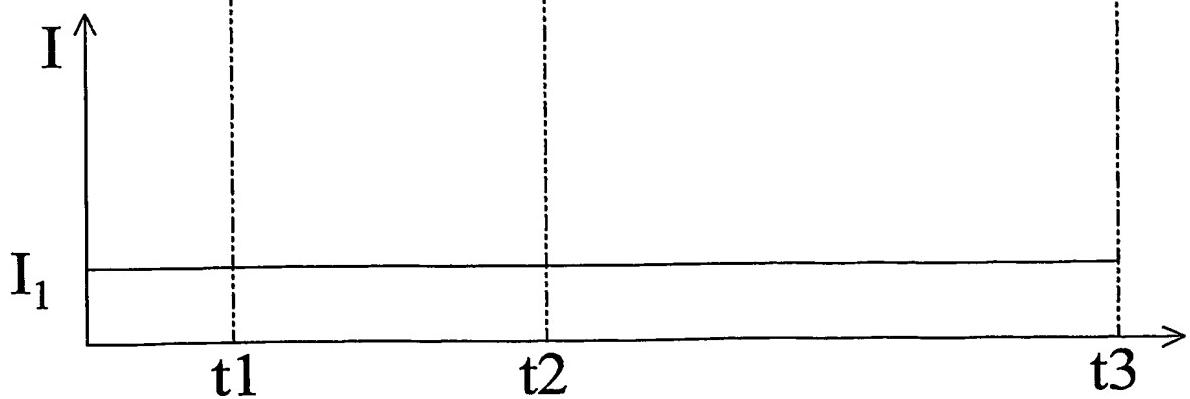
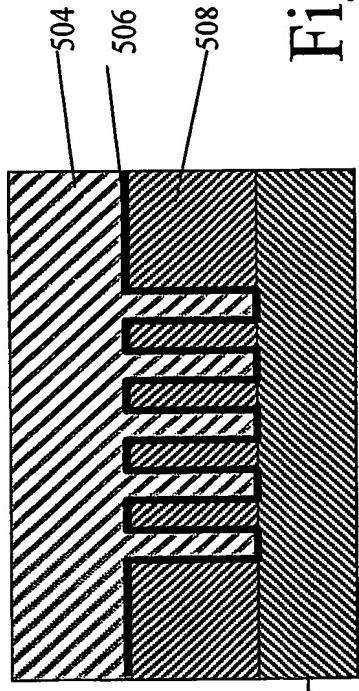
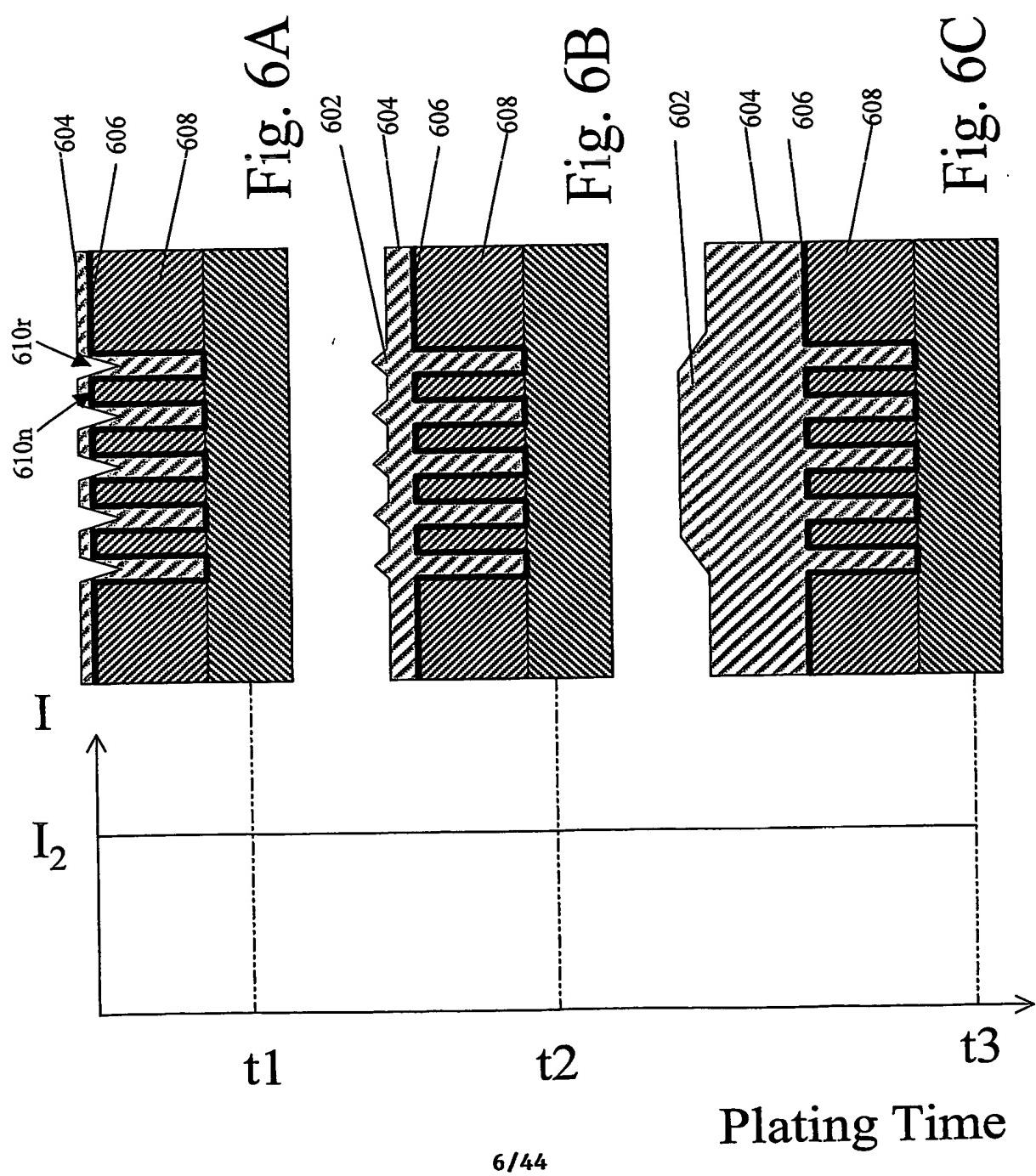


Fig. 5A**Fig. 5B****Fig. 5C**

Plating Time



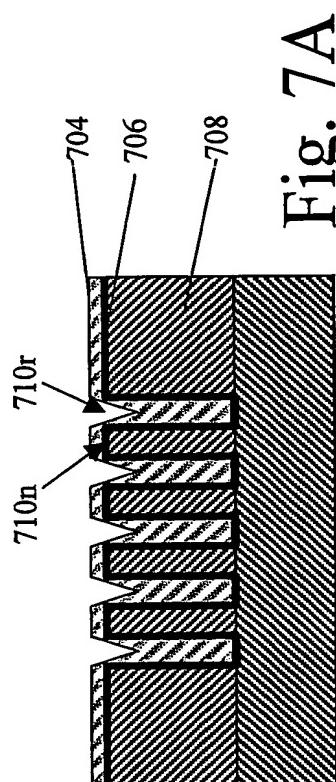


Fig. 7A

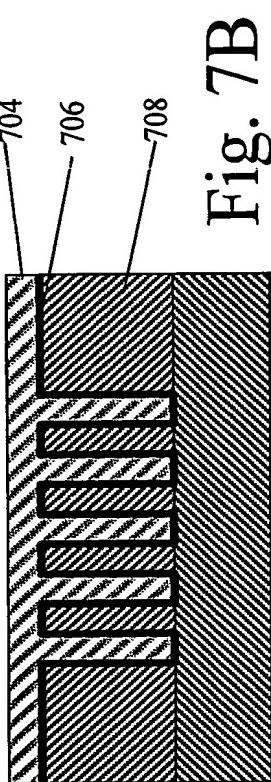


Fig. 7B

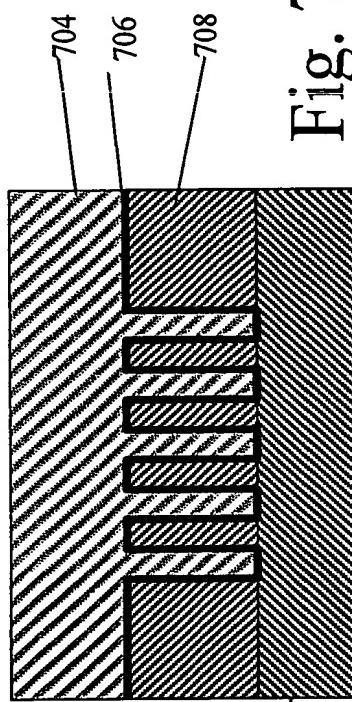
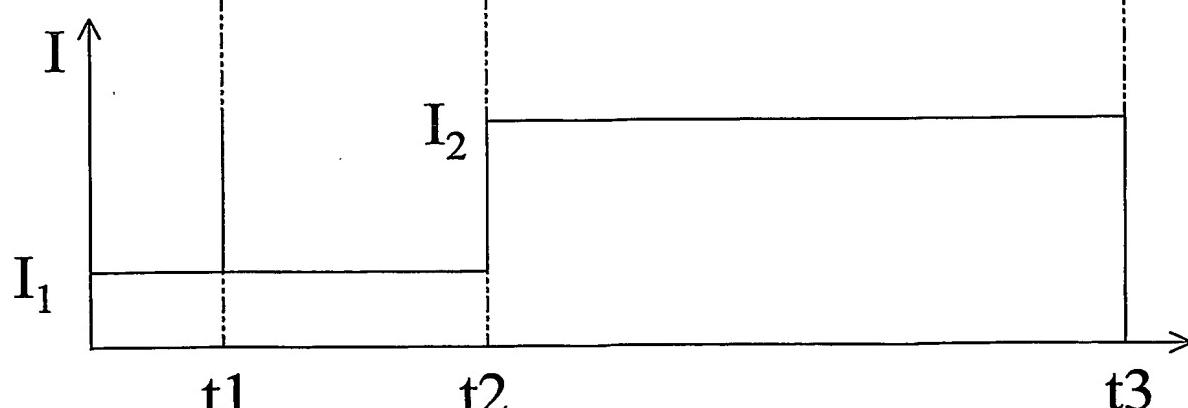
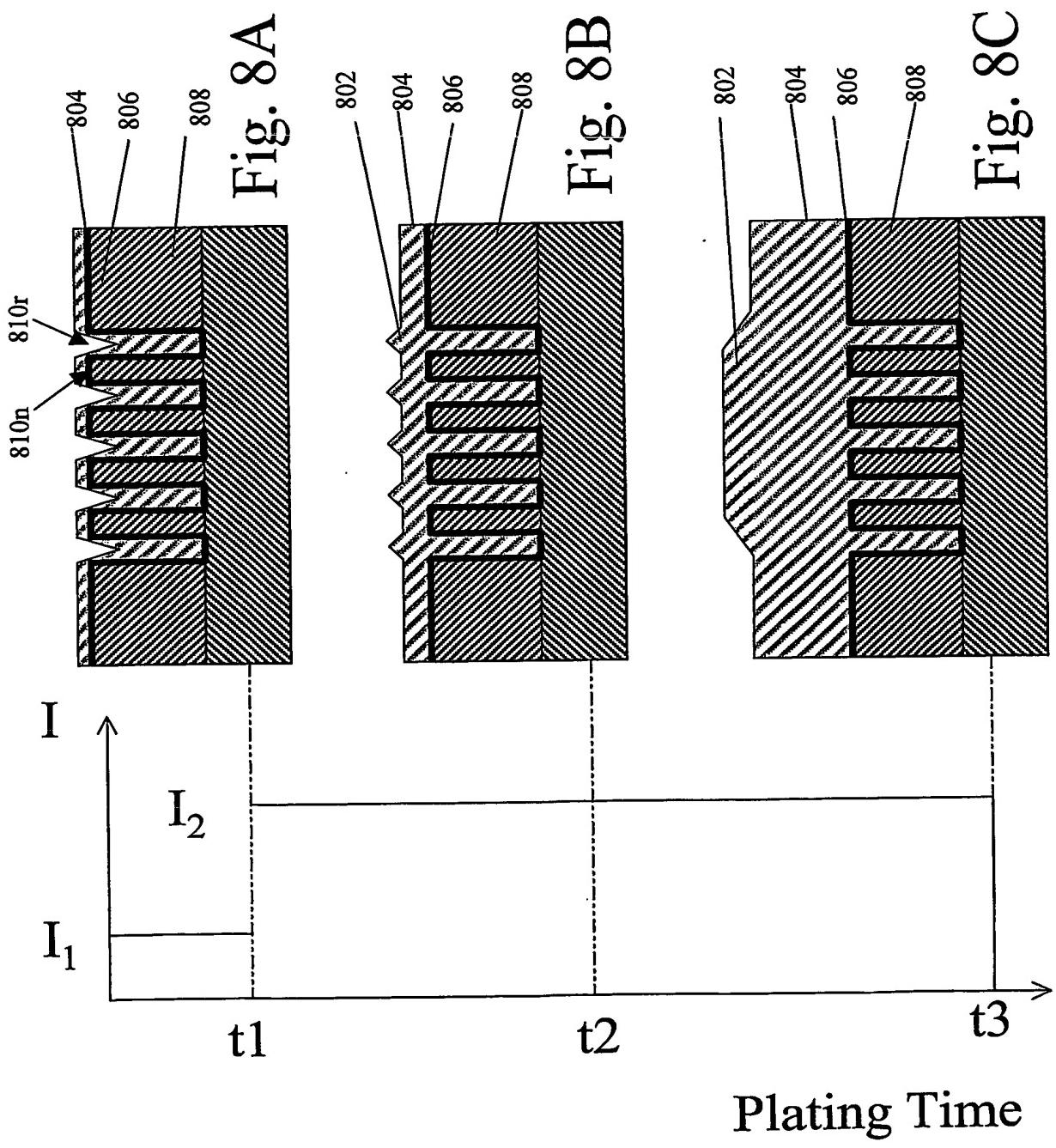


Fig. 7C



Plating Time



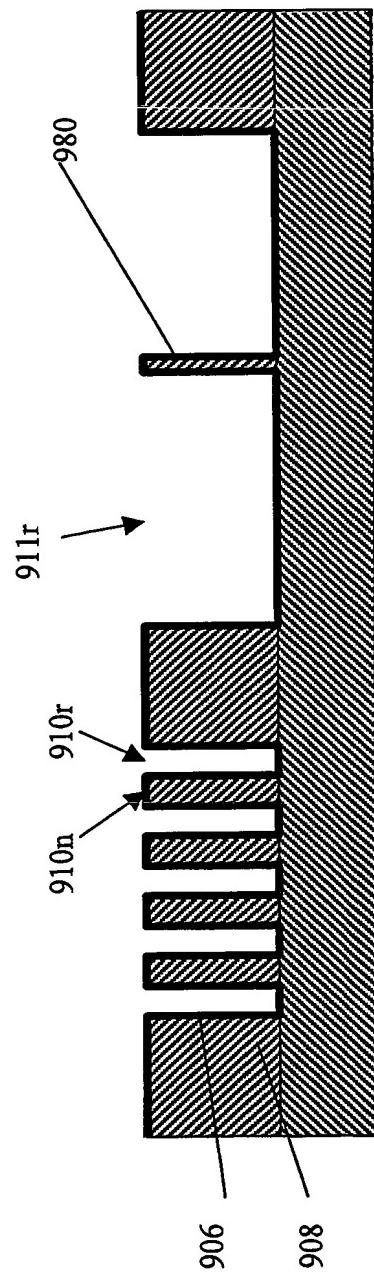
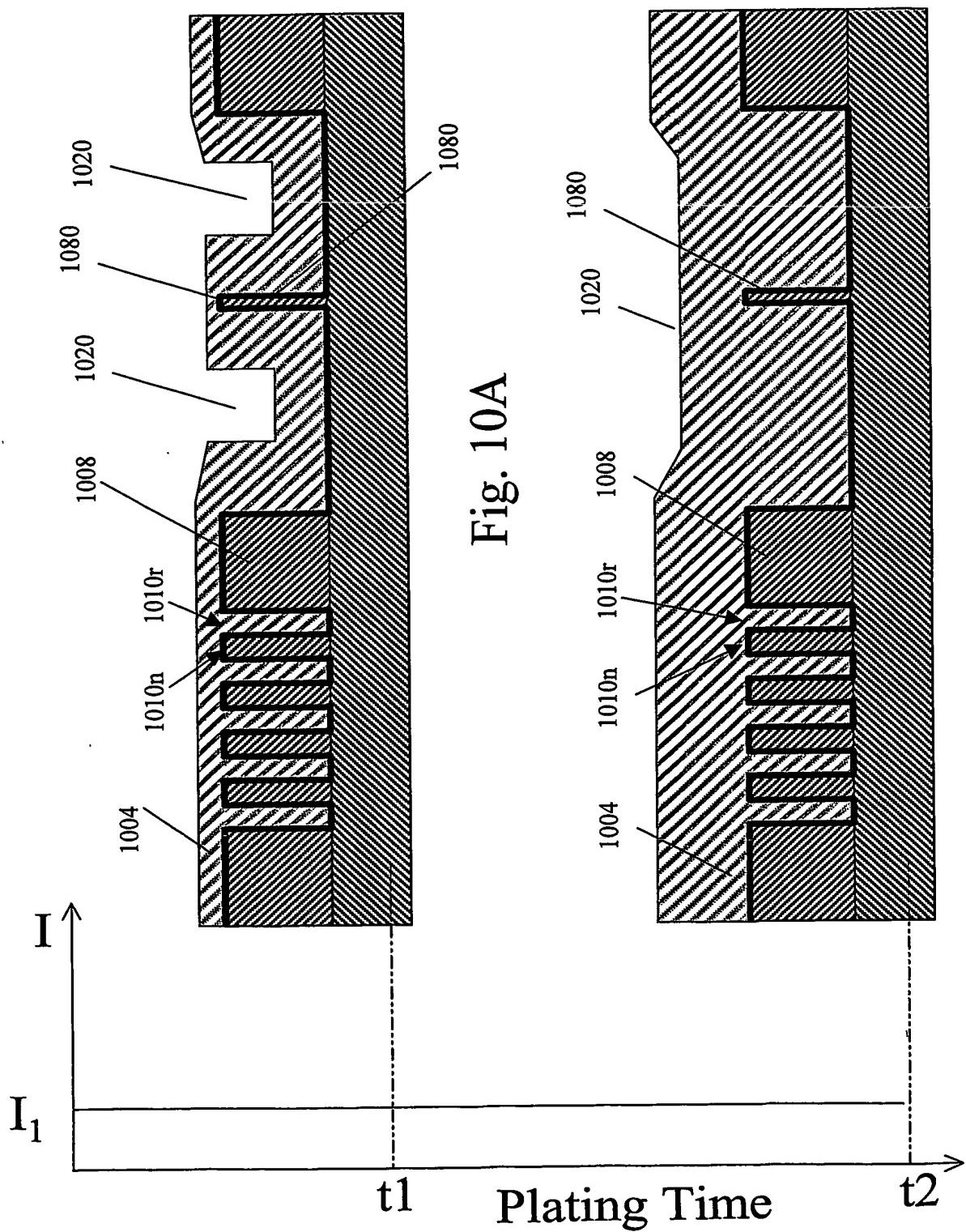
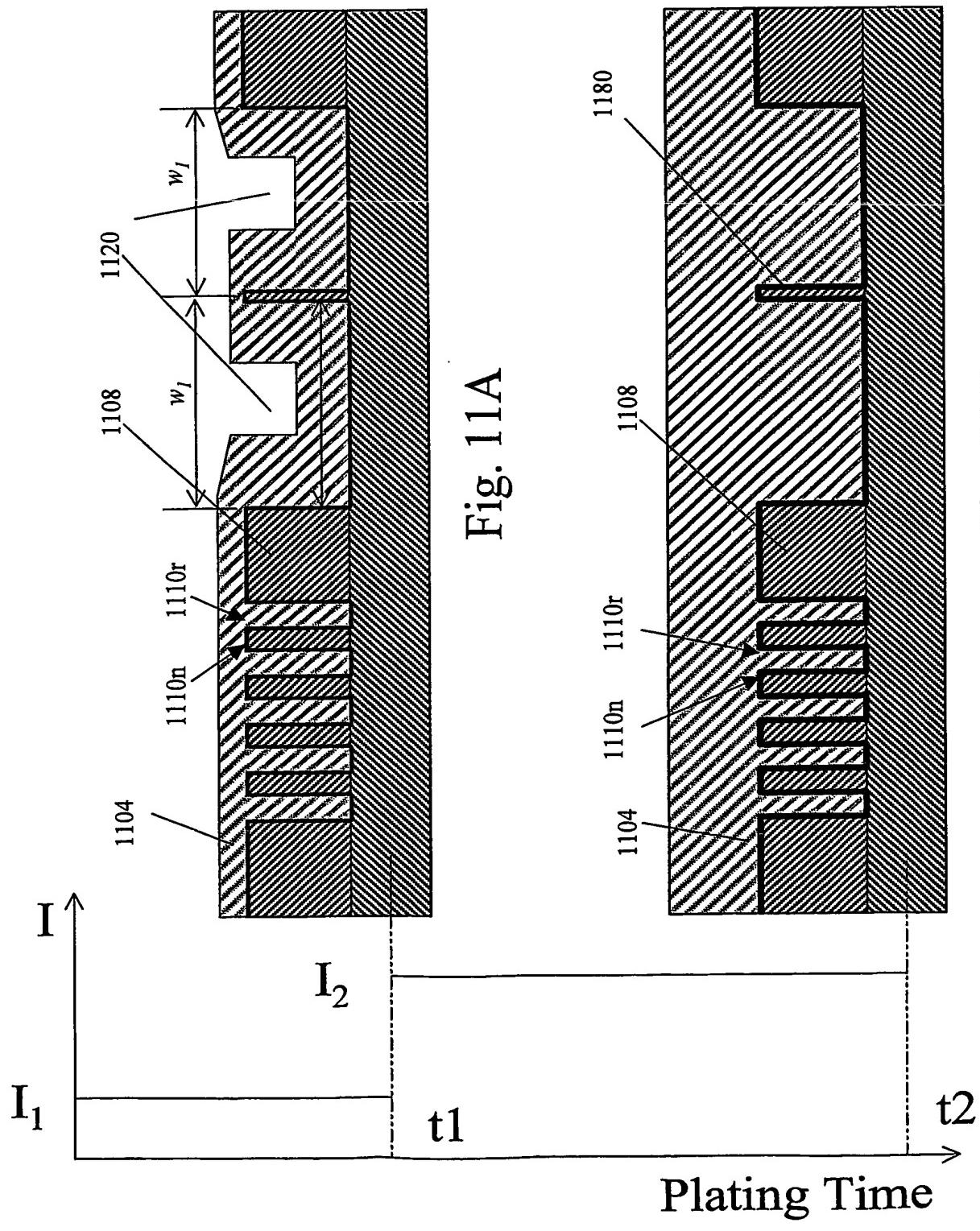
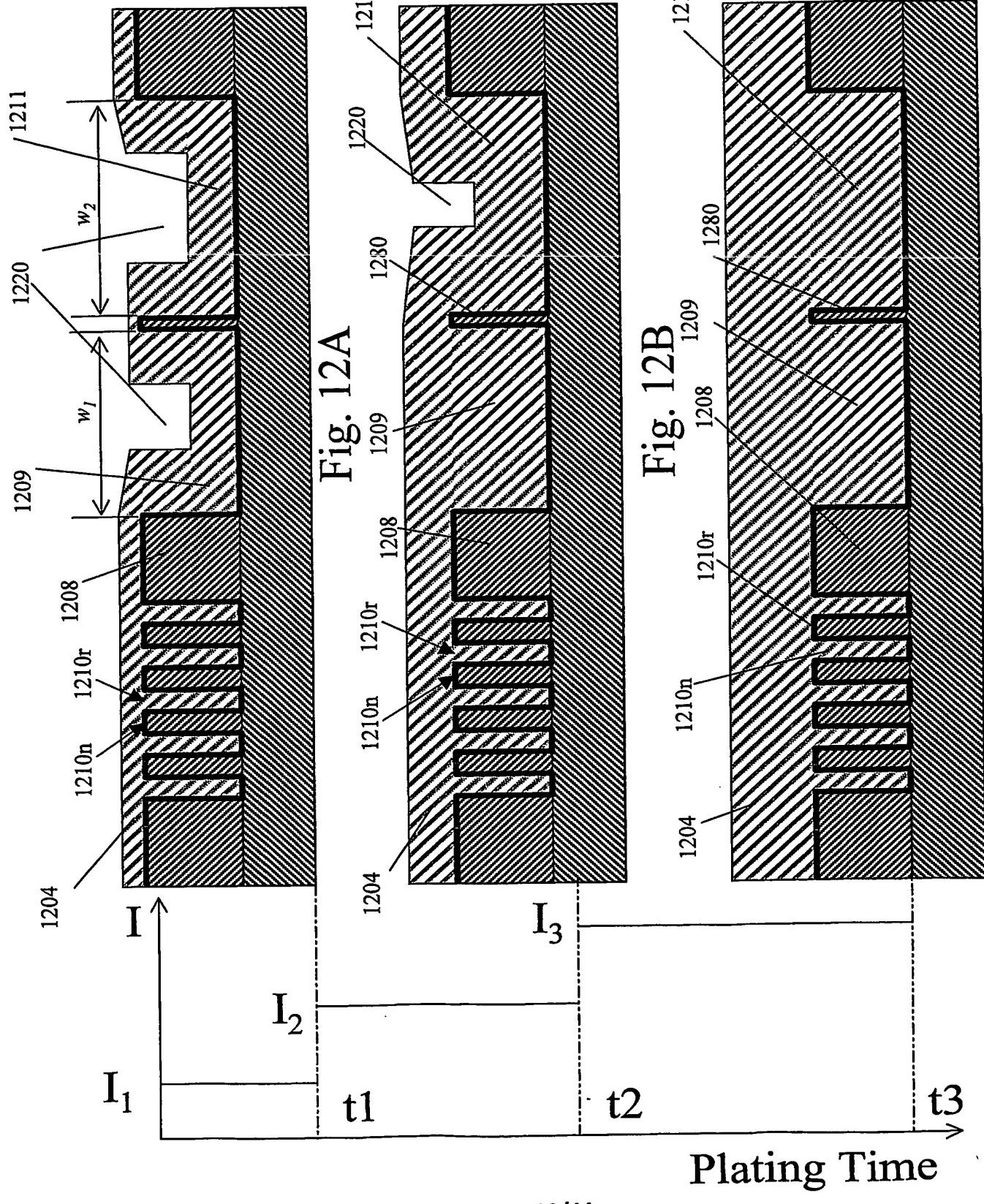


Fig. 9







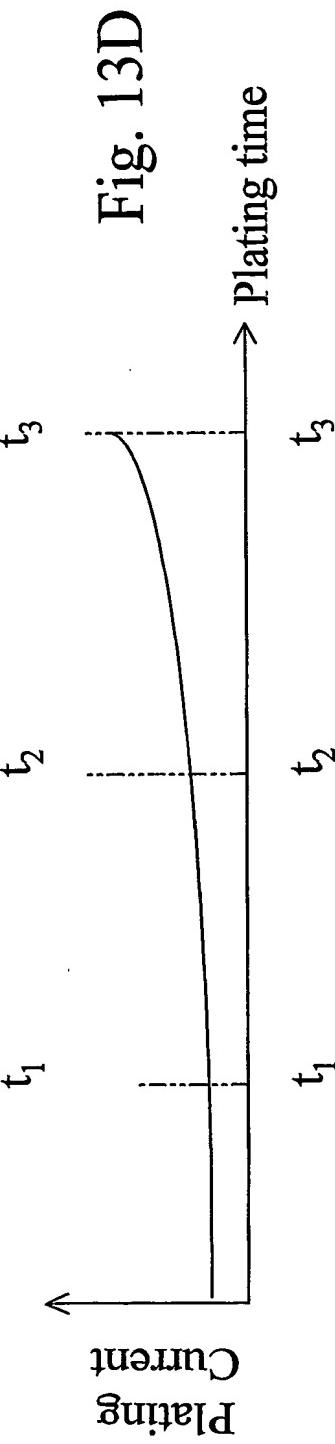
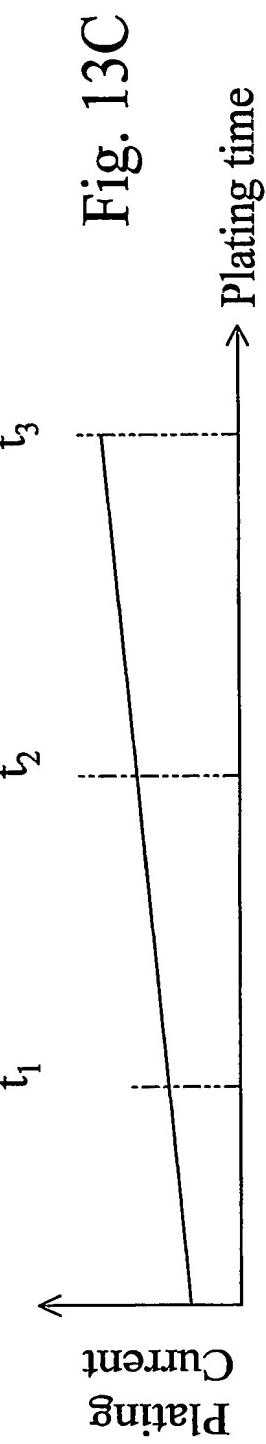
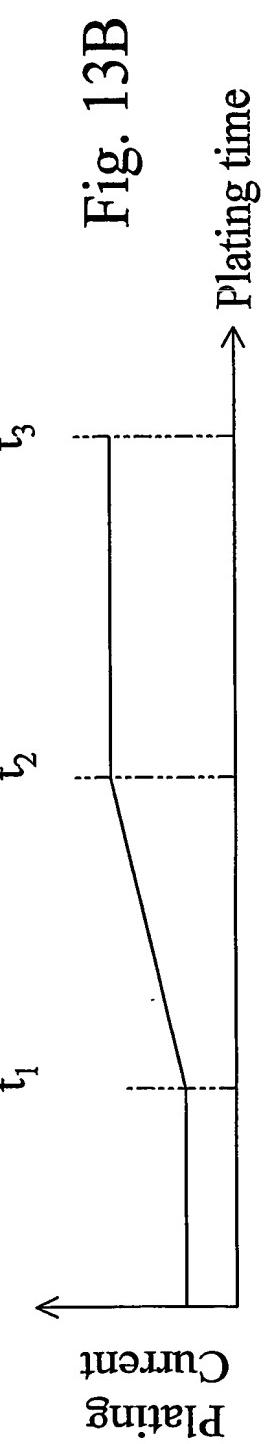
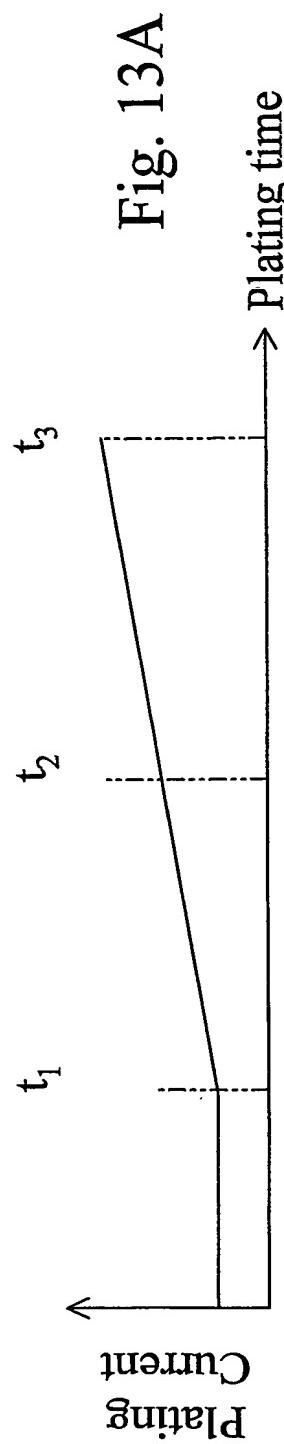


Fig. 13E

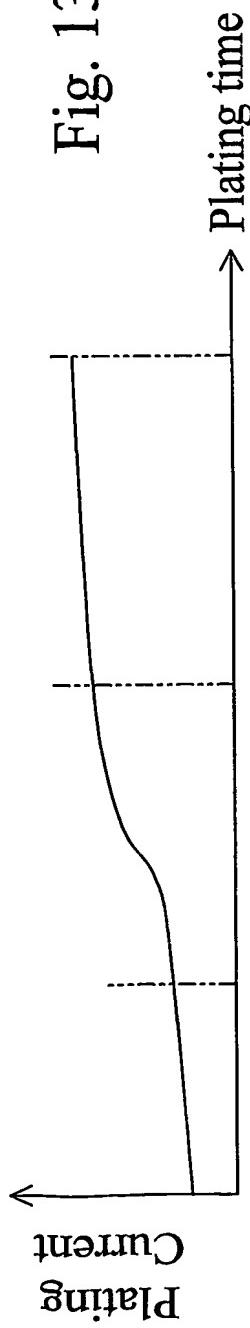


Fig. 13F

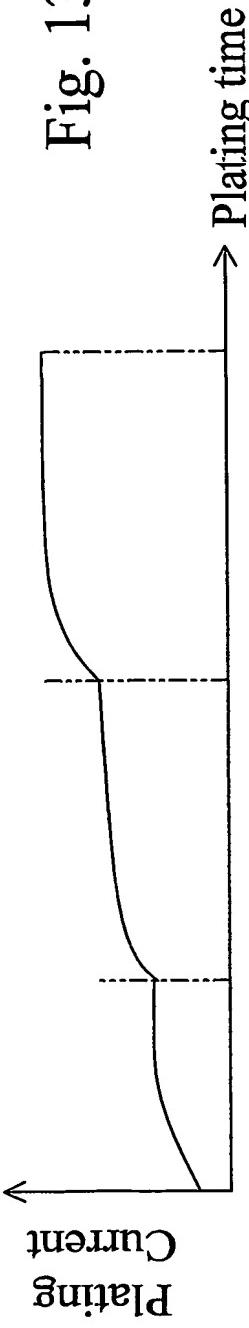


Fig. 13G

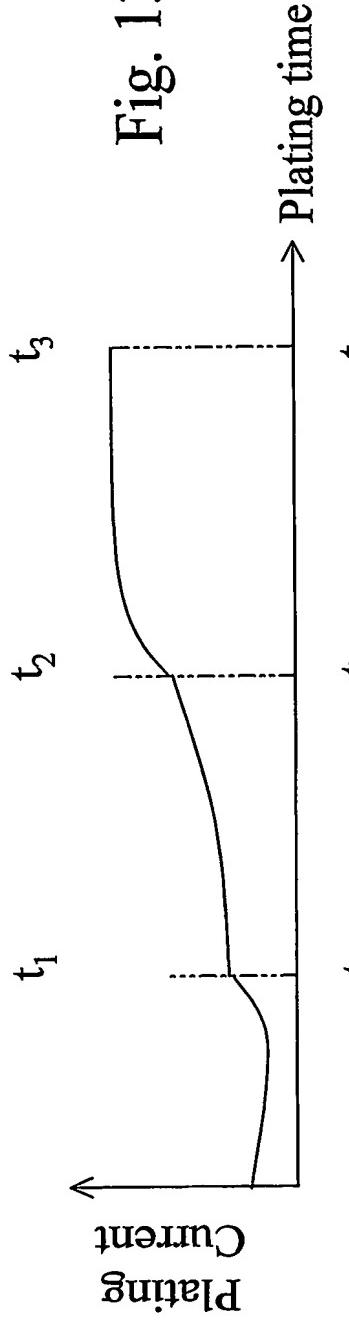
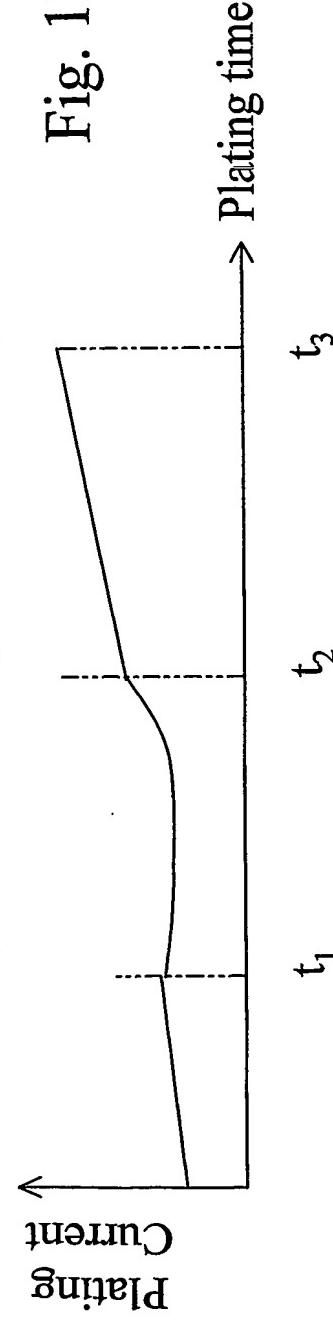


Fig. 13H



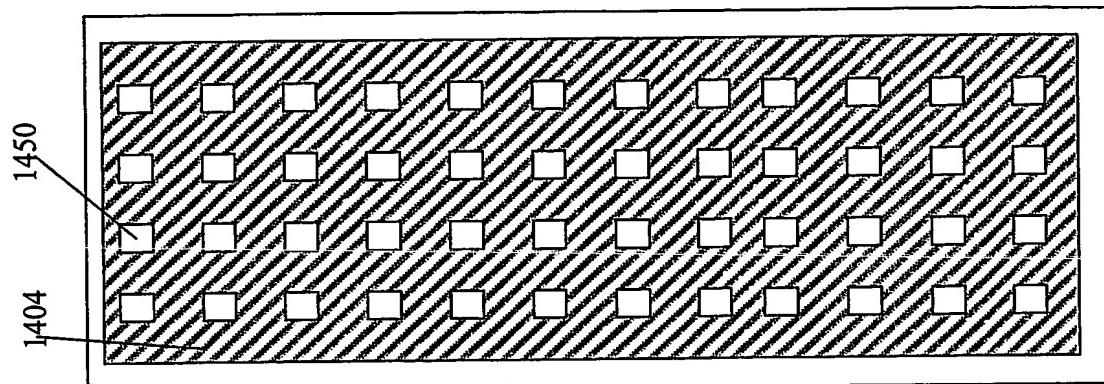


Fig. 14C

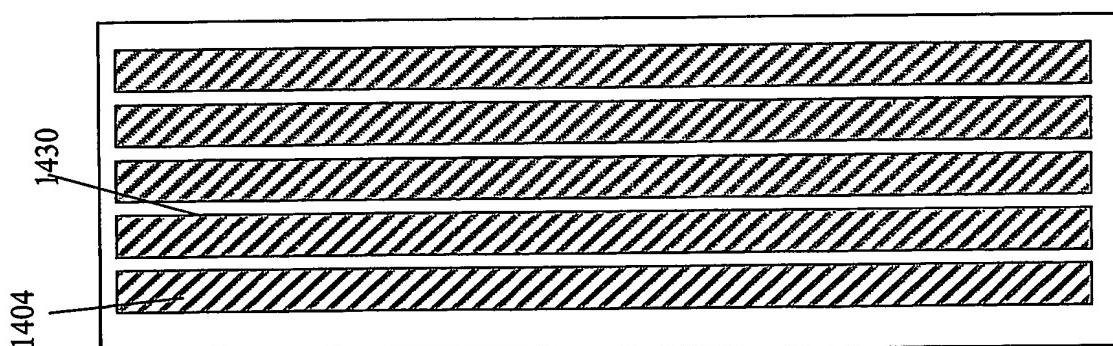


Fig. 14B

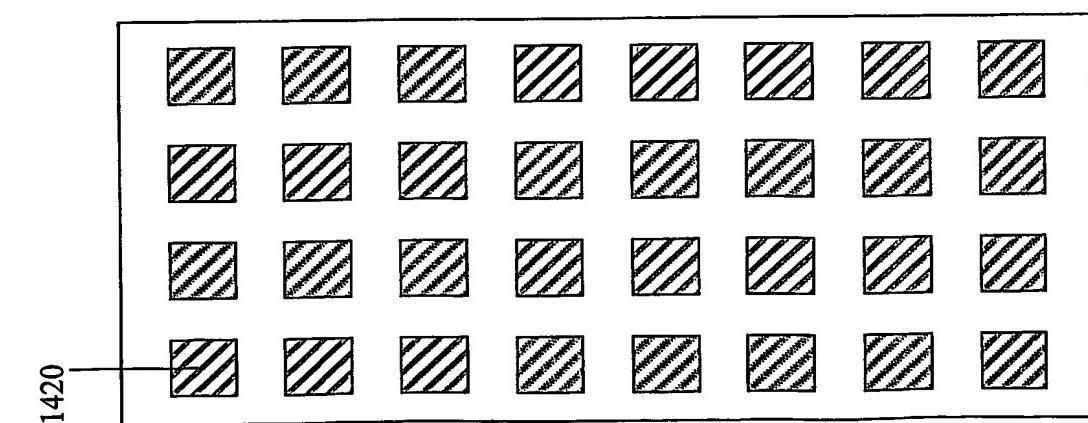


Fig. 14A

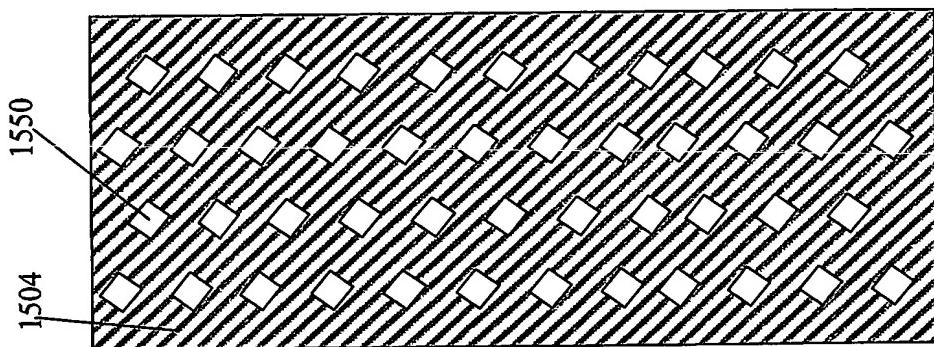


Fig. 15C

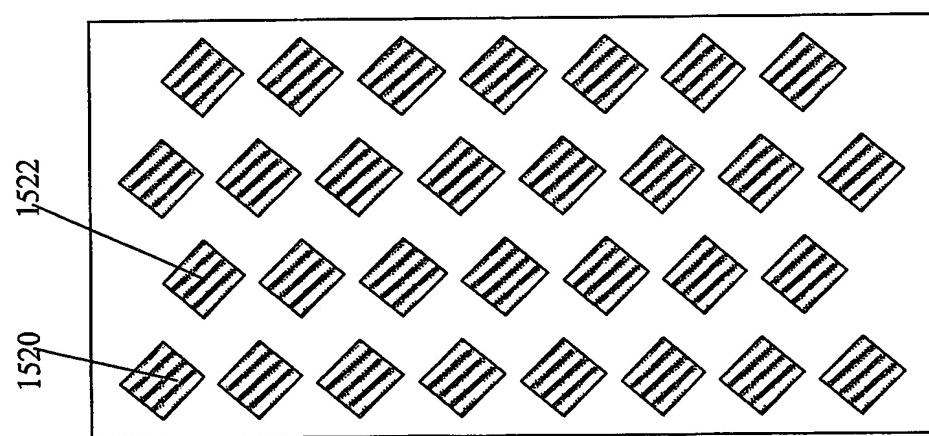


Fig. 15B

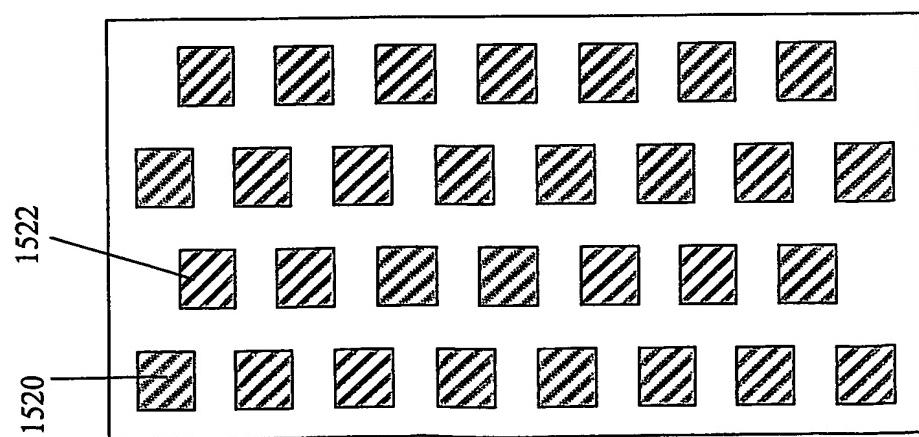


Fig. 15A

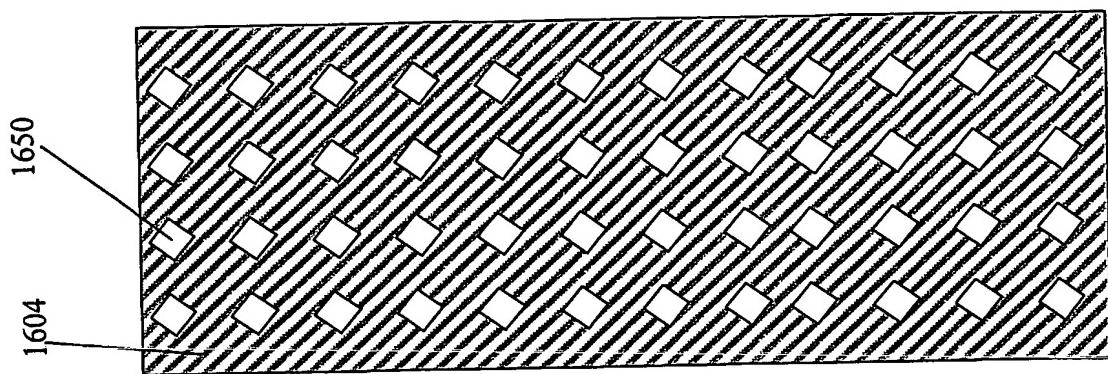


Fig. 16C

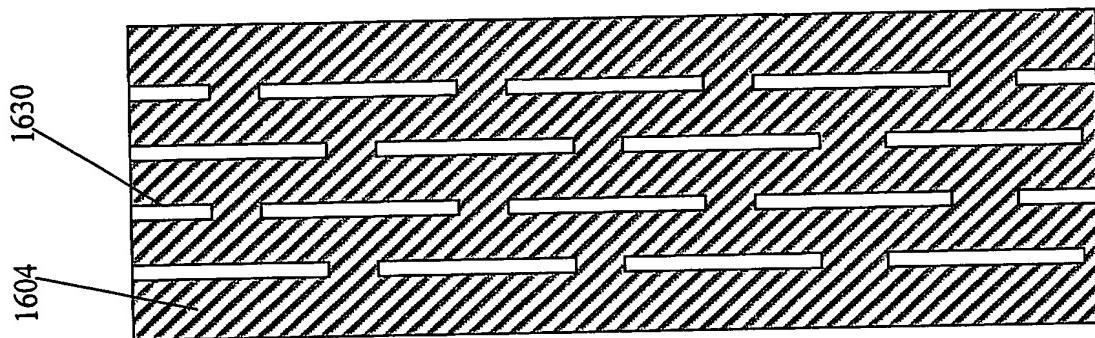


Fig. 16B

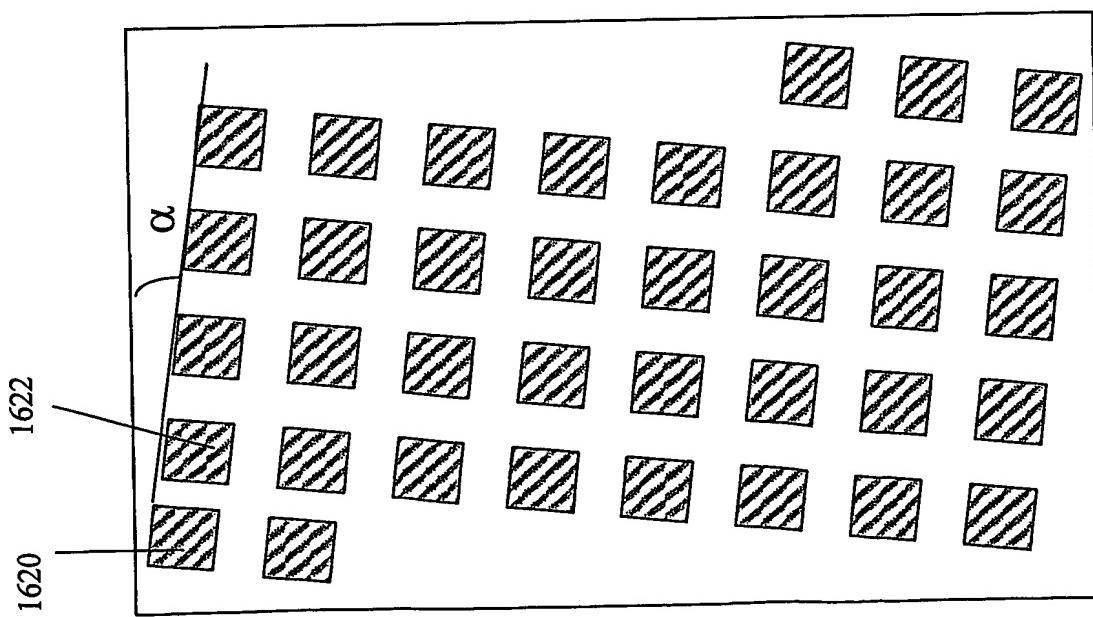


Fig. 16A

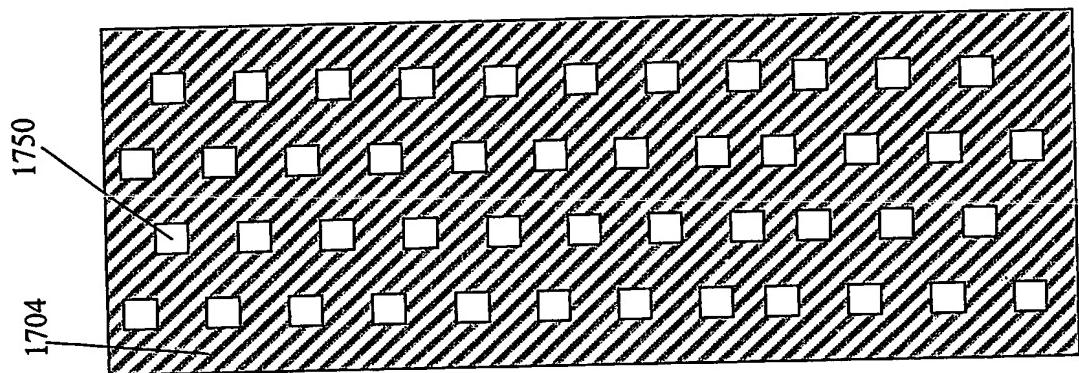


Fig. 17C

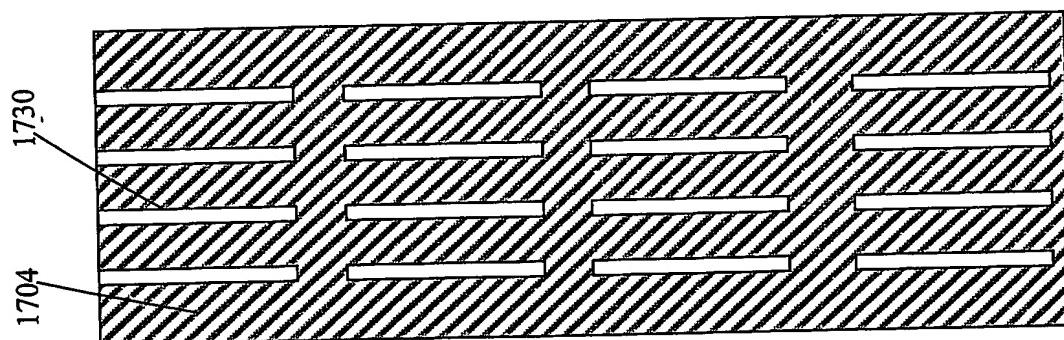


Fig. 17B

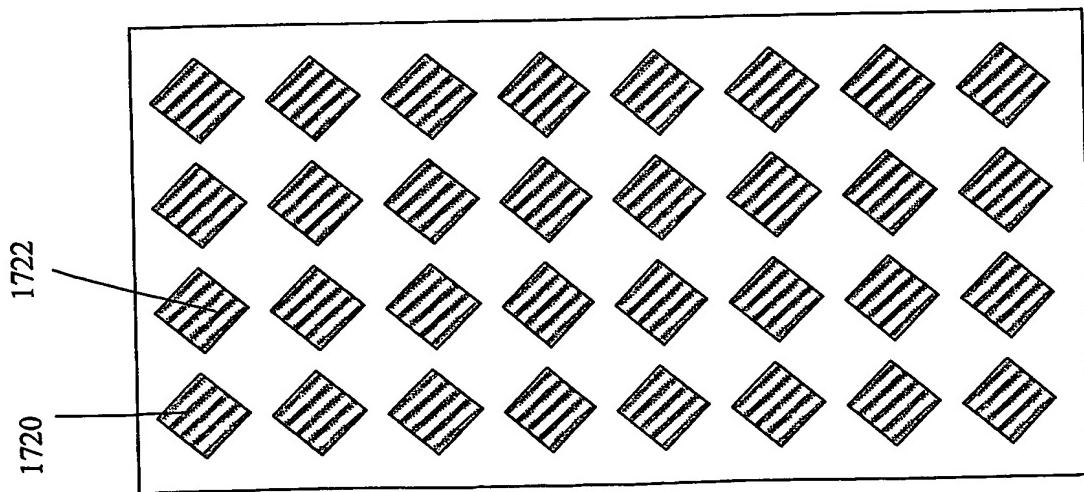


Fig. 17A

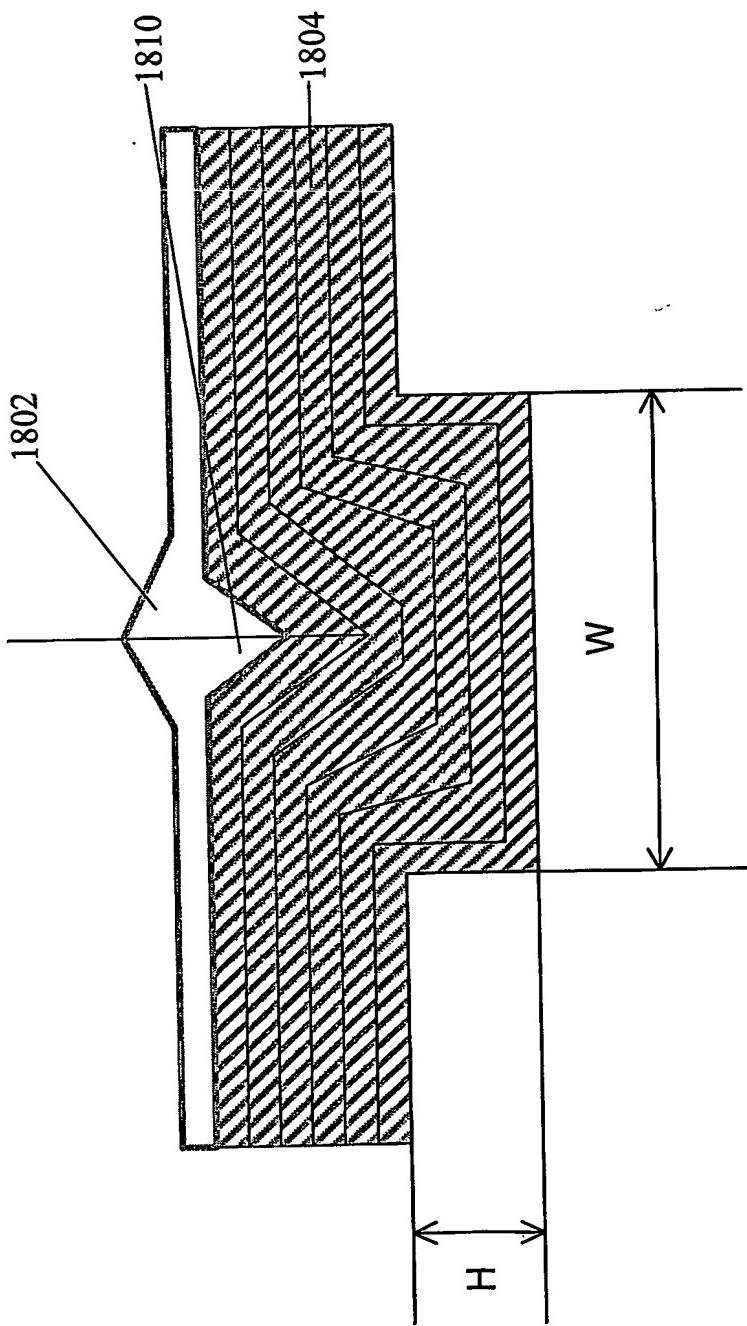


Fig. 18A

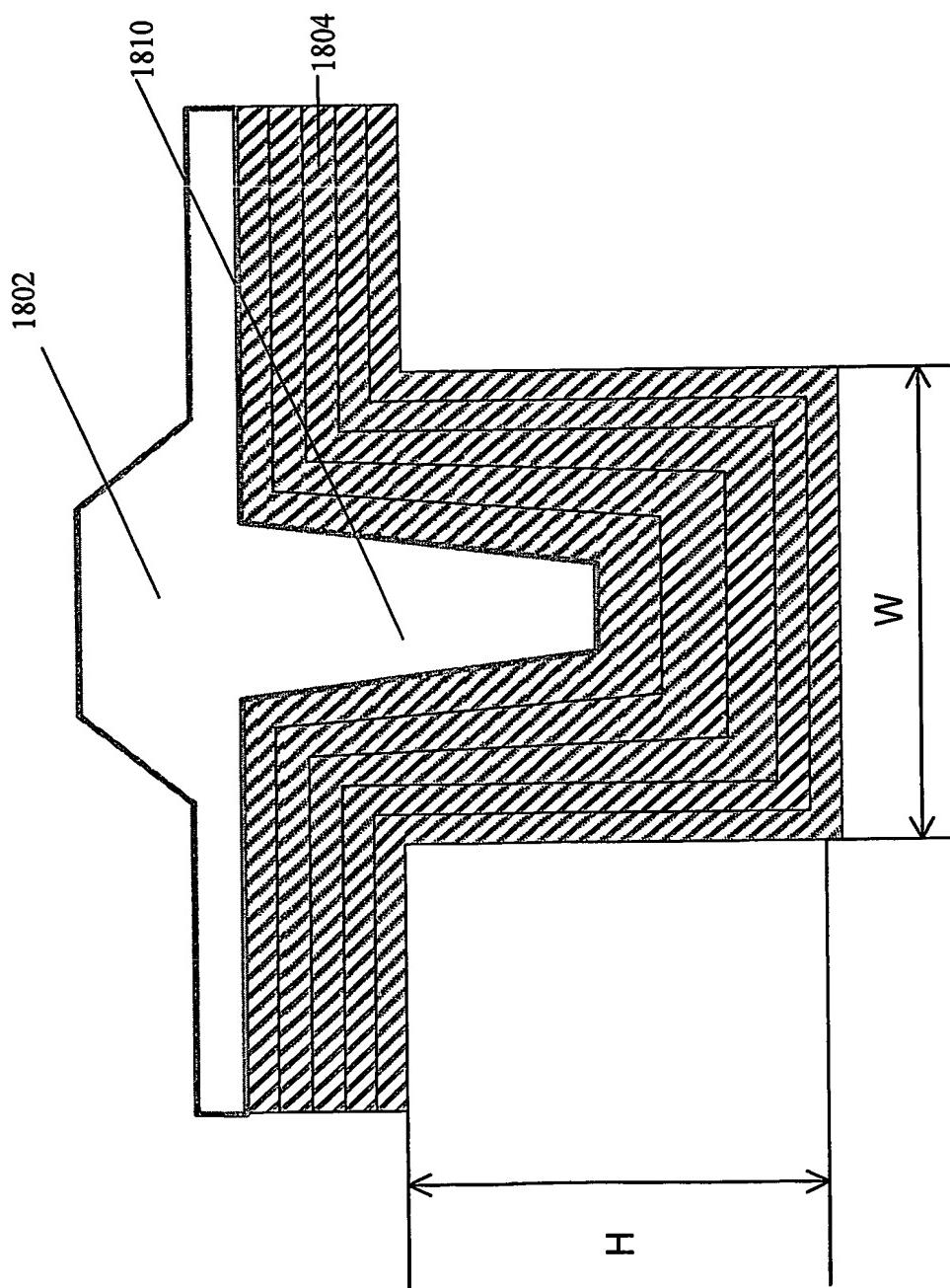
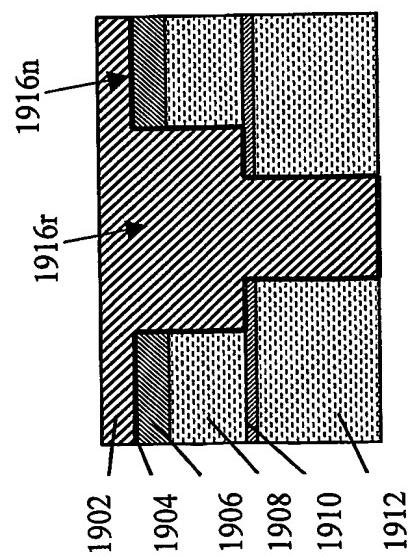
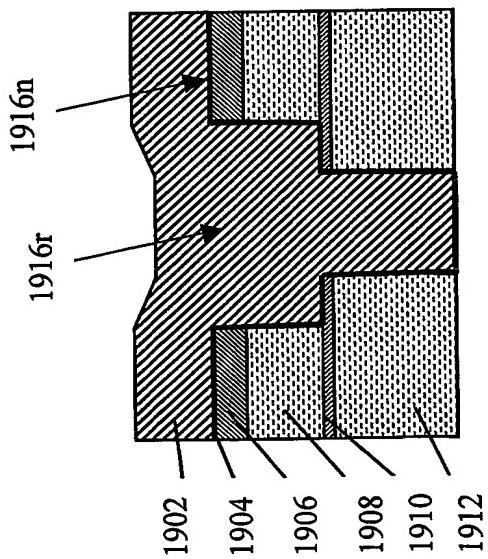
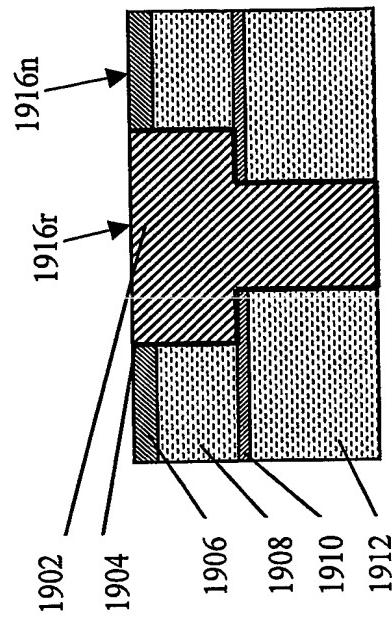
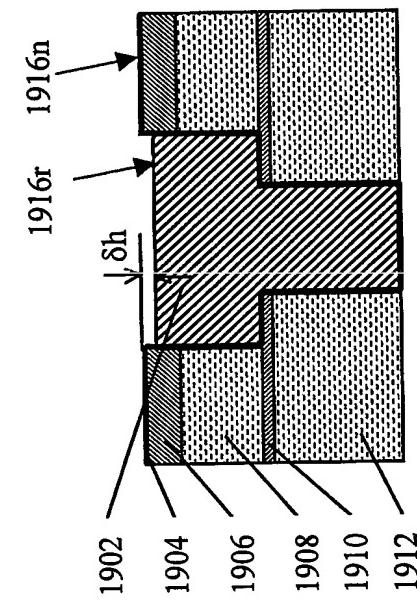


Fig. 18B



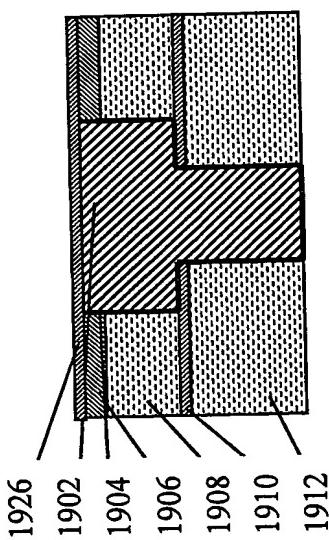


Fig. 19E

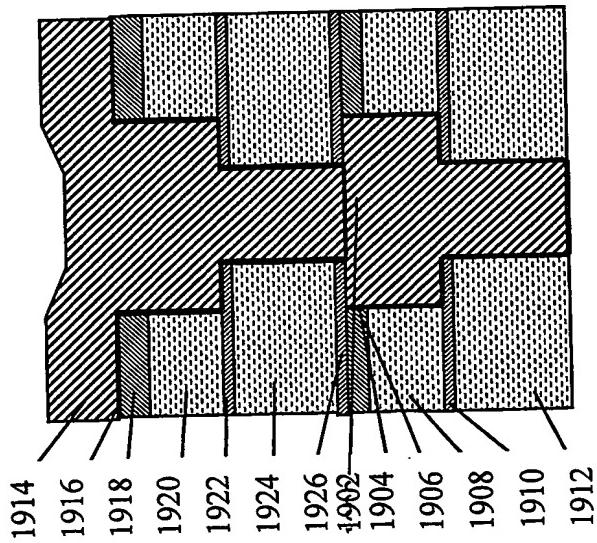


Fig. 19F

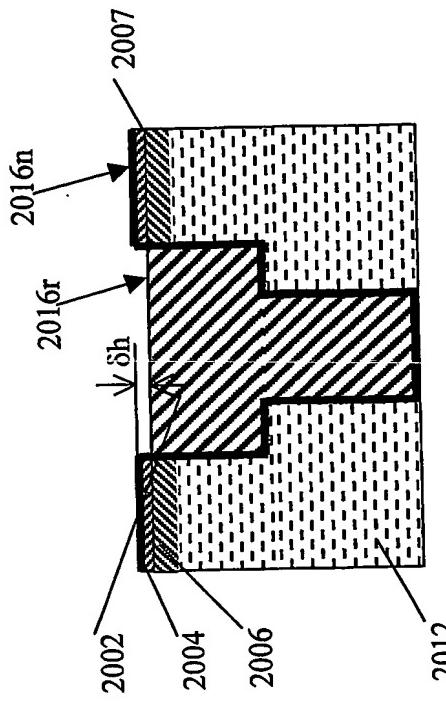


Fig. 20C

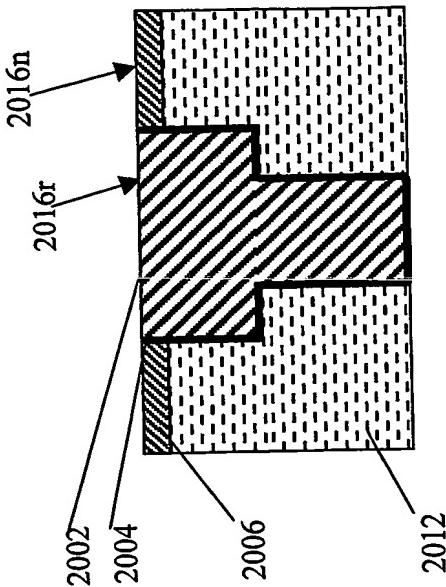


Fig. 20D

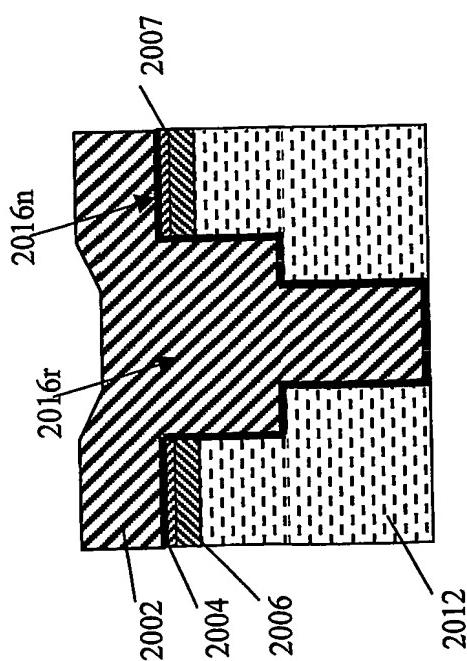


Fig. 20A

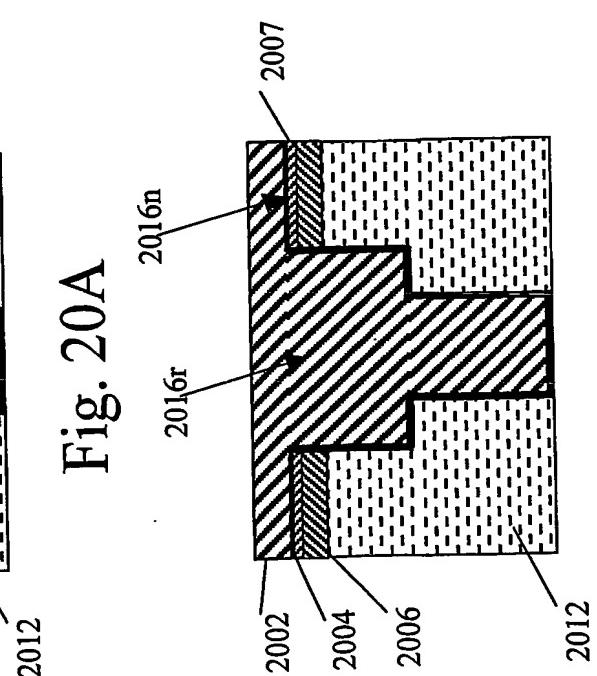


Fig. 20B

Fig. 21A

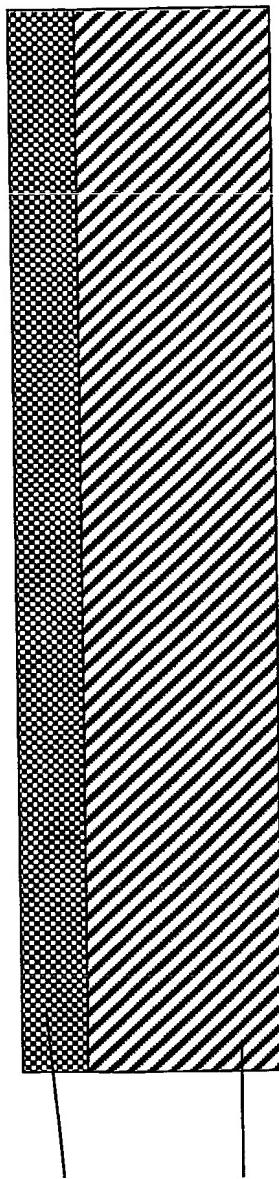


Fig. 21B

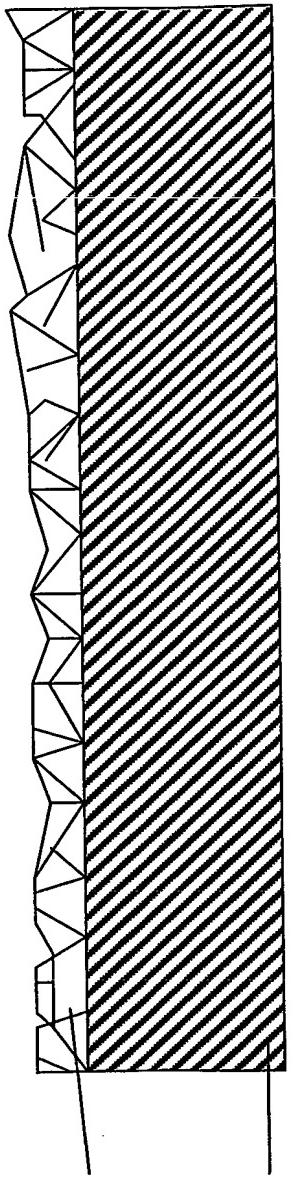


Fig. 21C

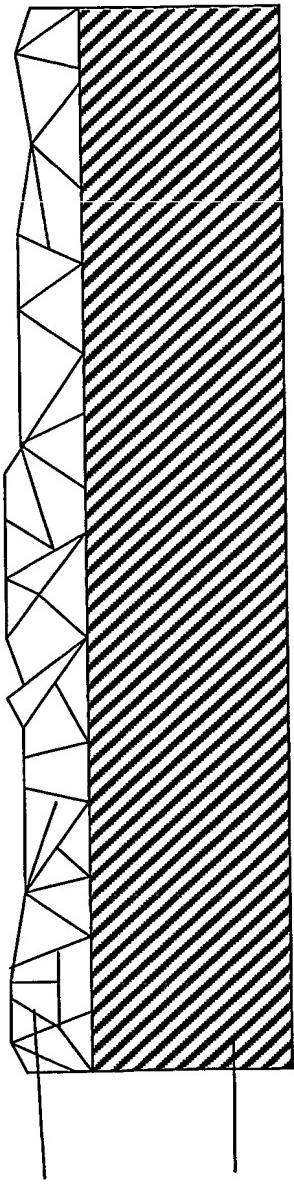
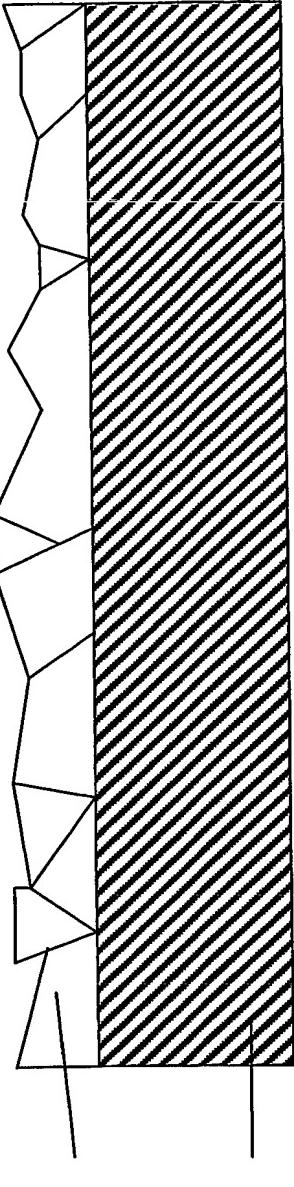


Fig. 21D



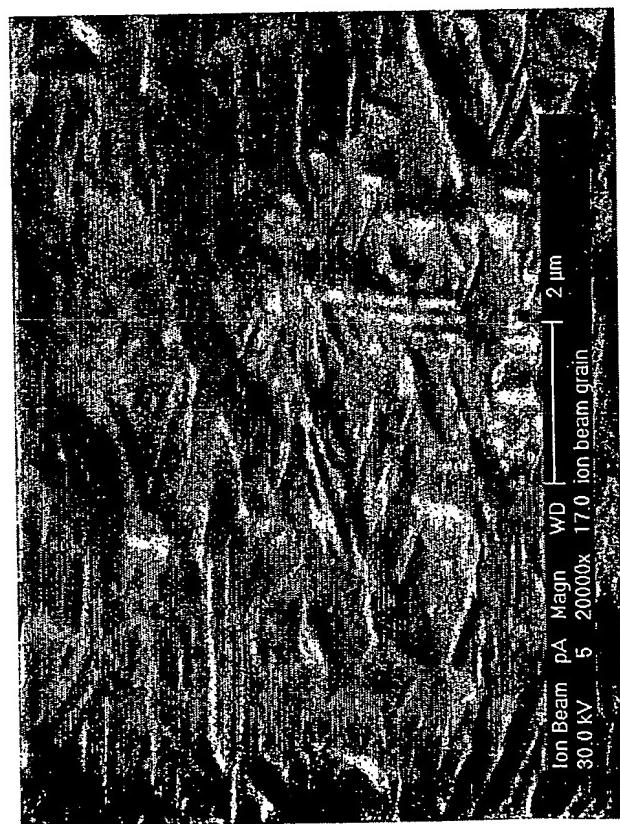
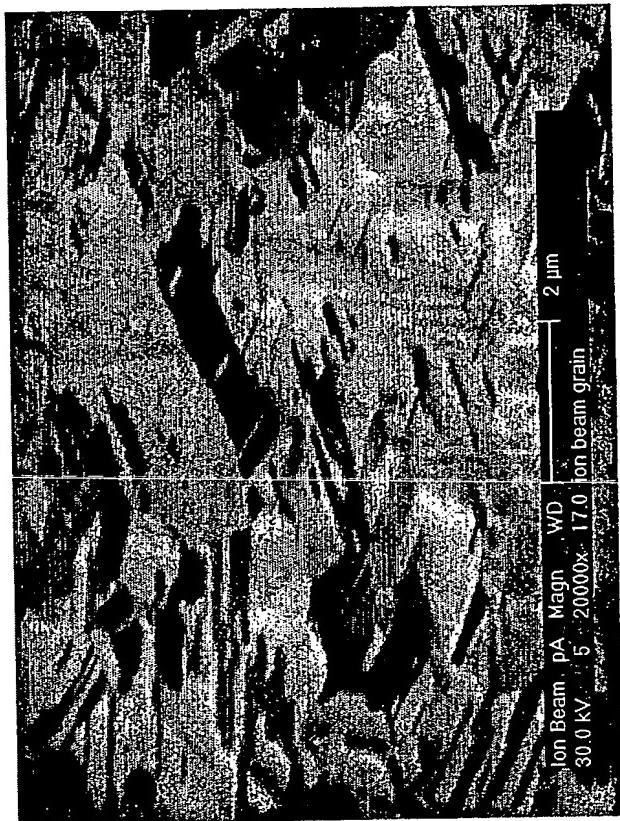


Fig. 22B

Fig. 22A

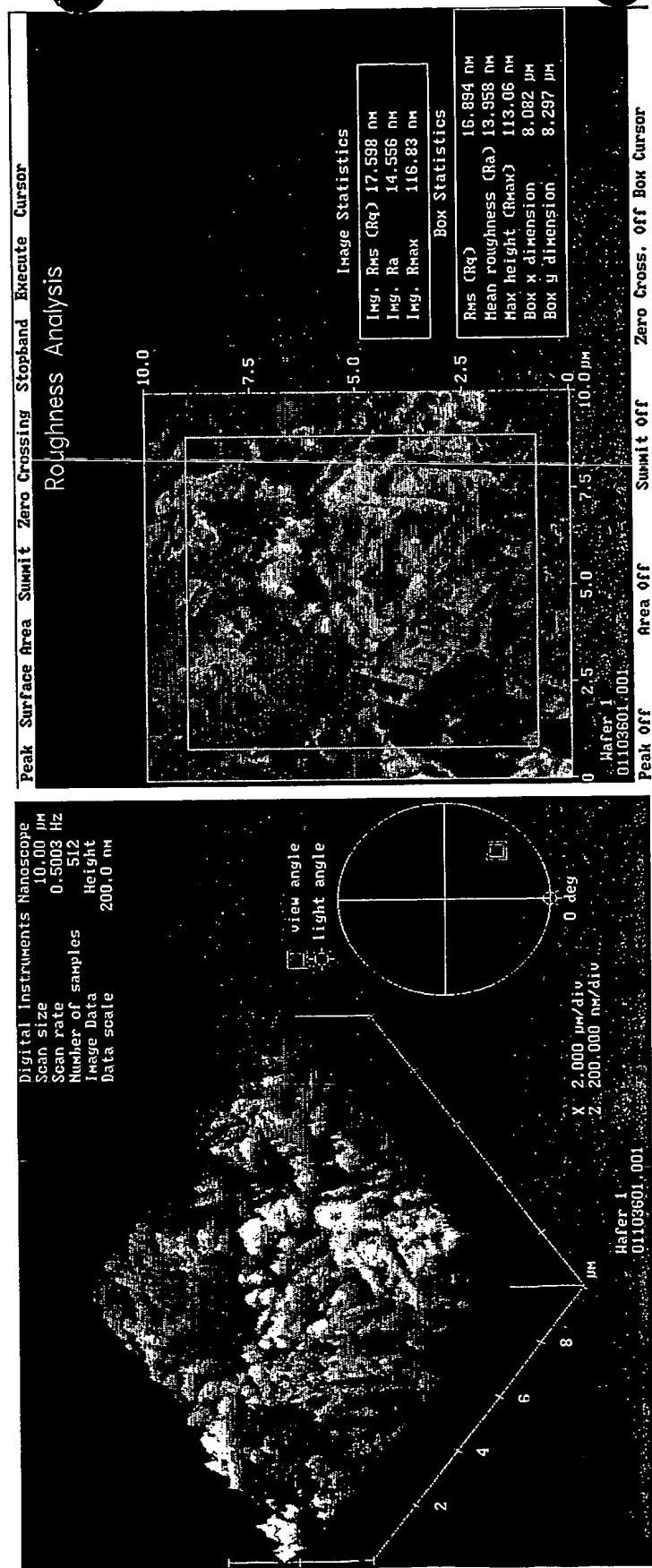


Fig. 22C

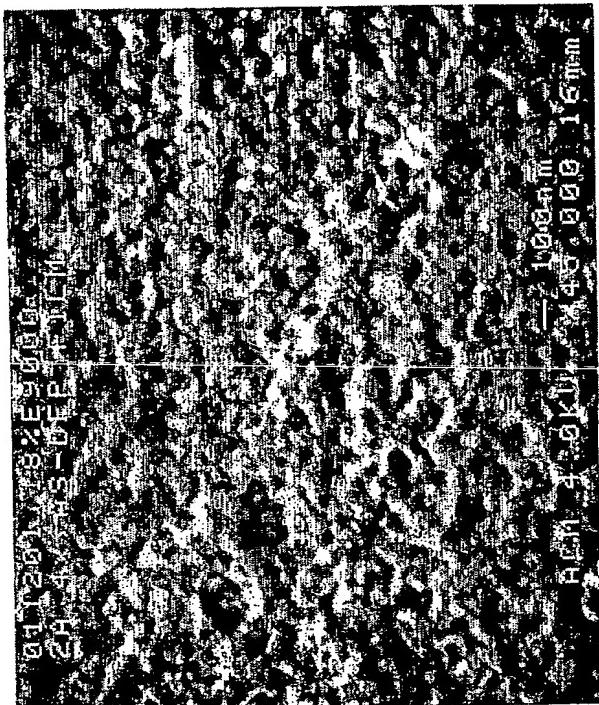


Fig. 23B

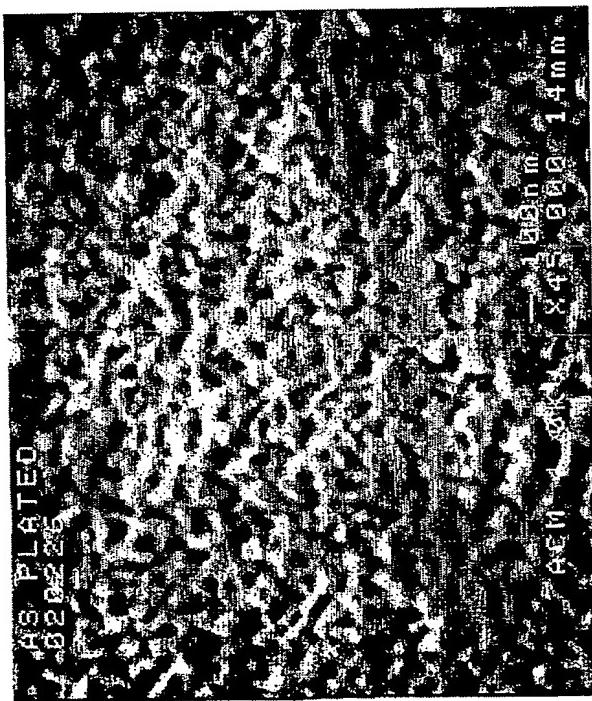


Fig. 23A

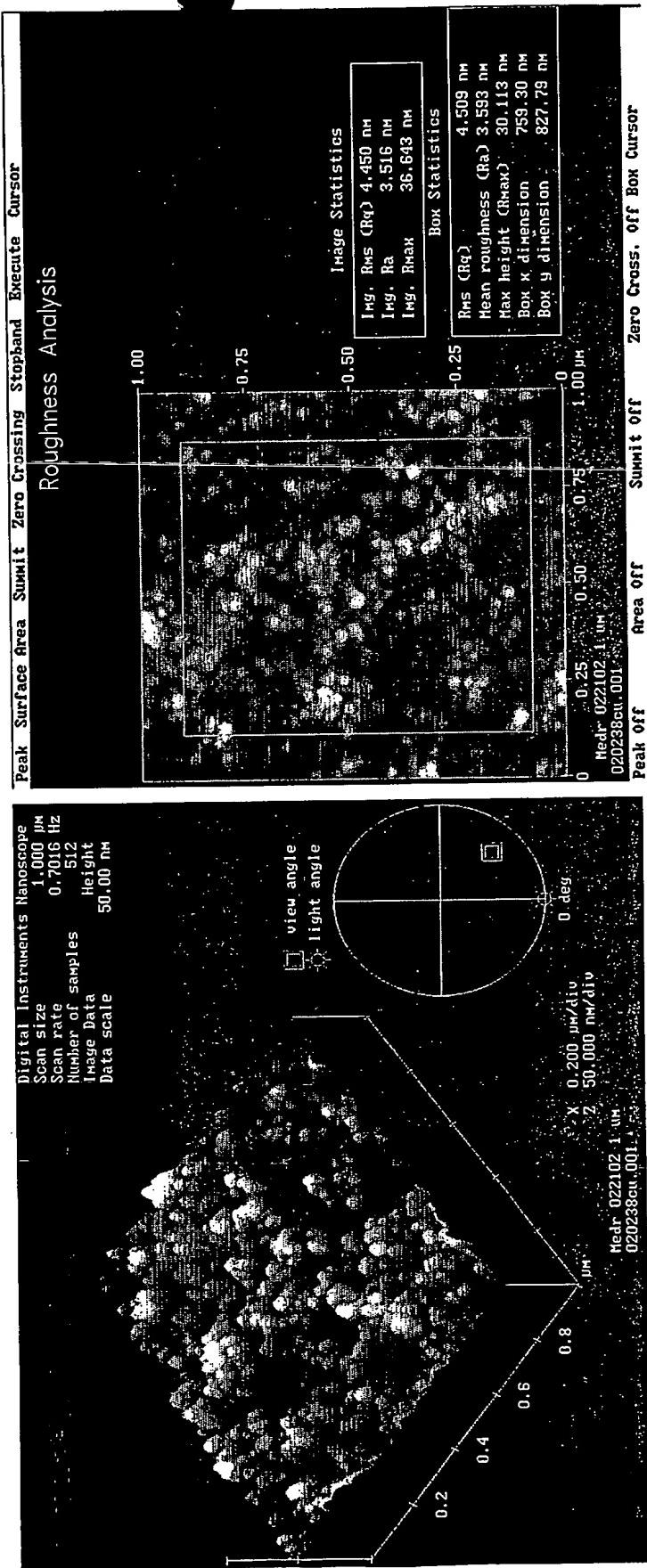


Fig. 23C

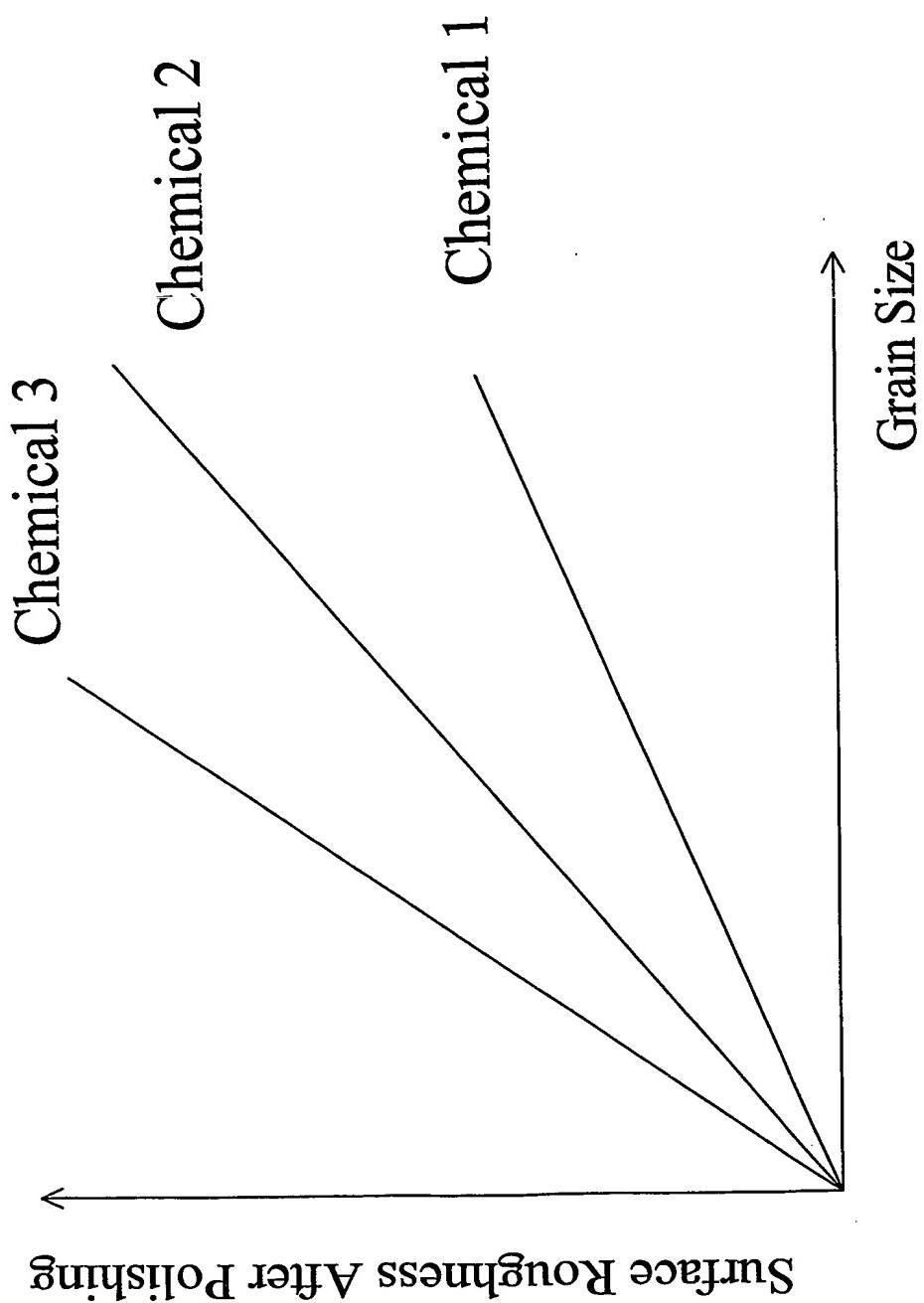


Fig. 24

Fig. 25A

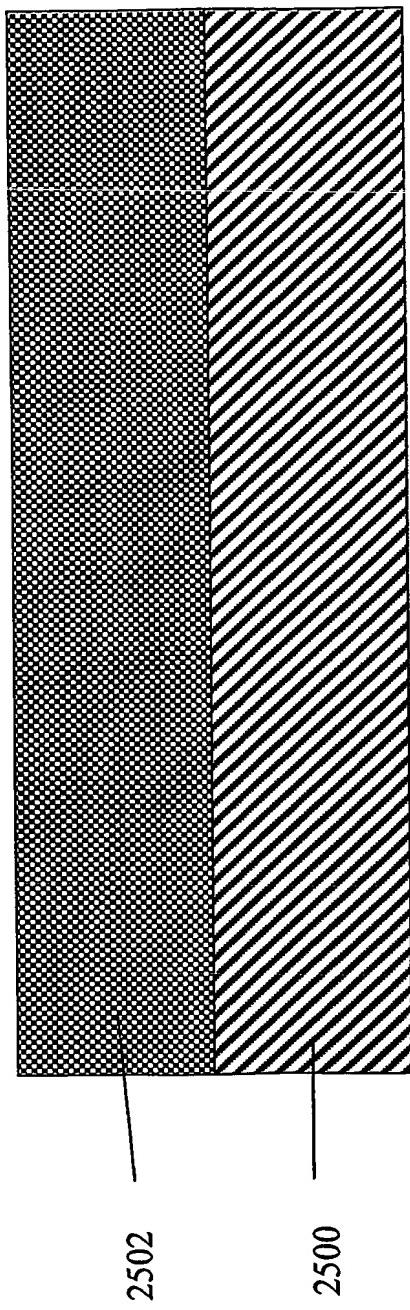


Fig. 25B

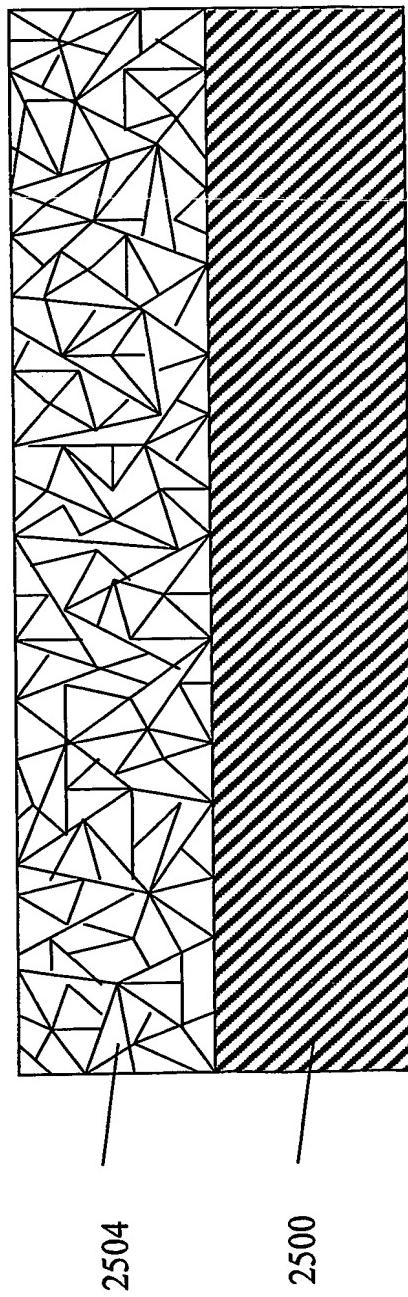


Fig. 25C

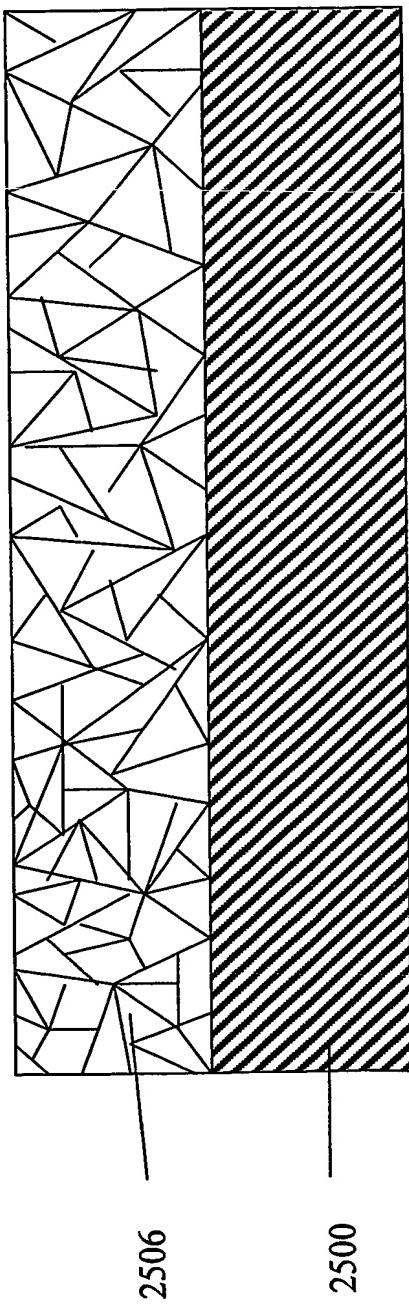
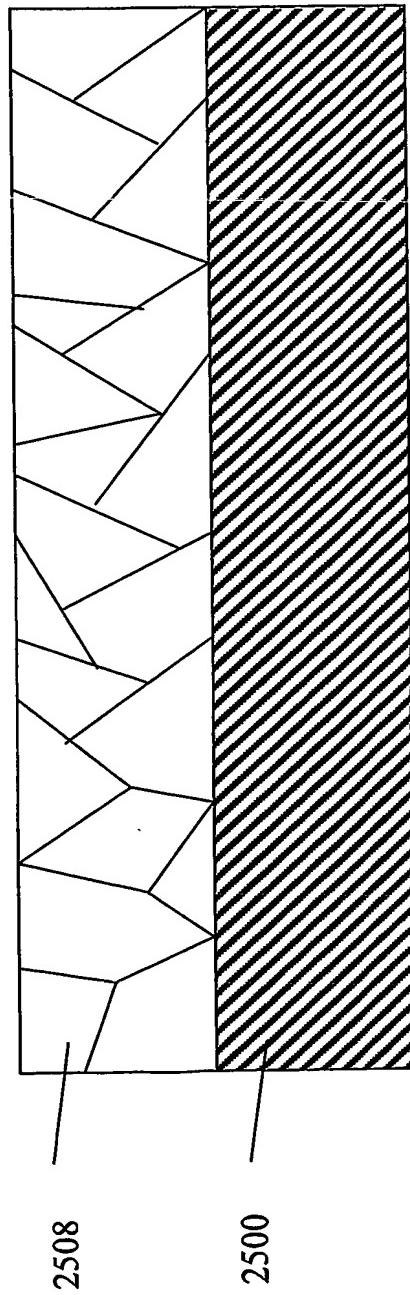


Fig. 25D



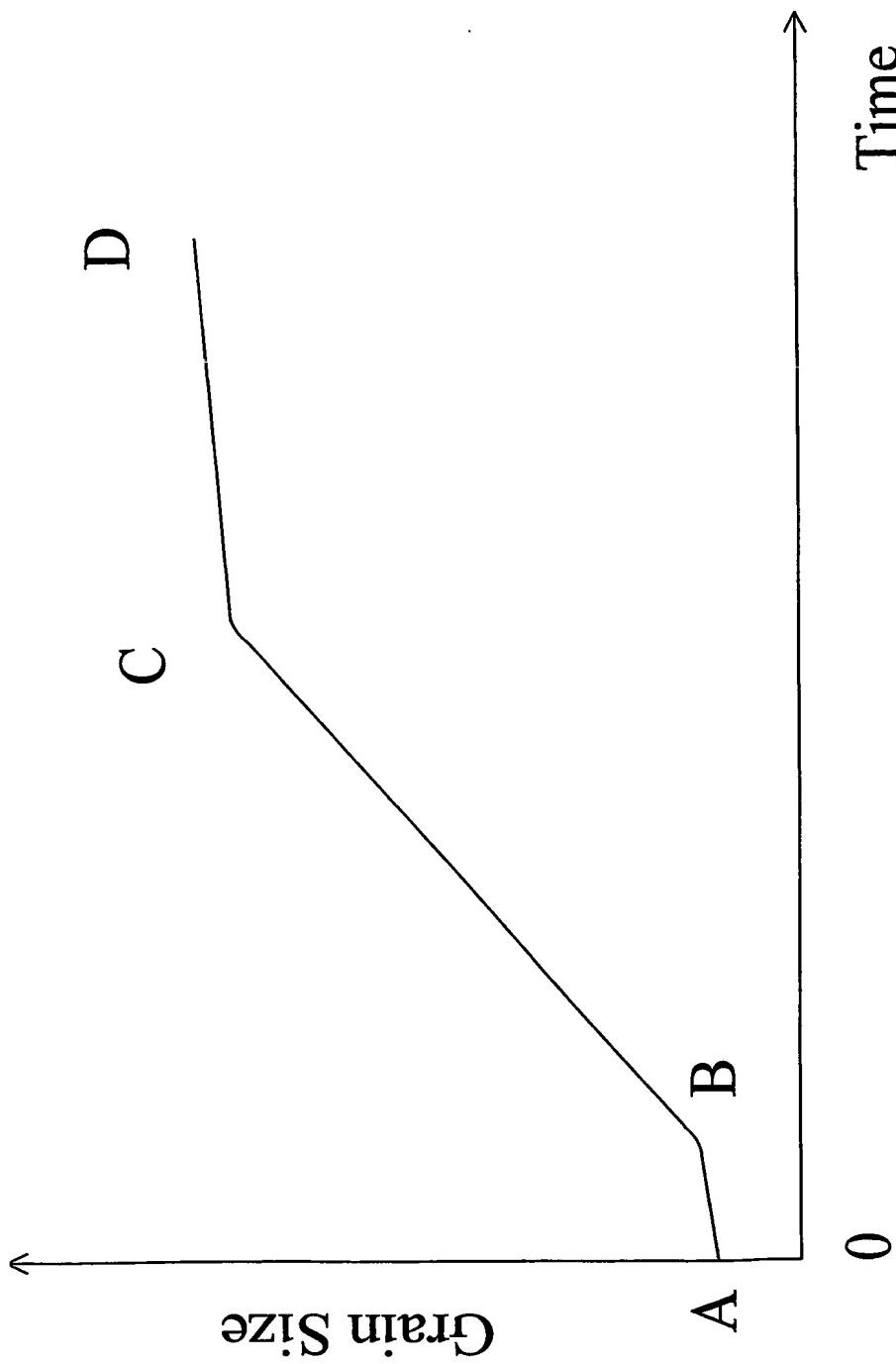


Fig. 26

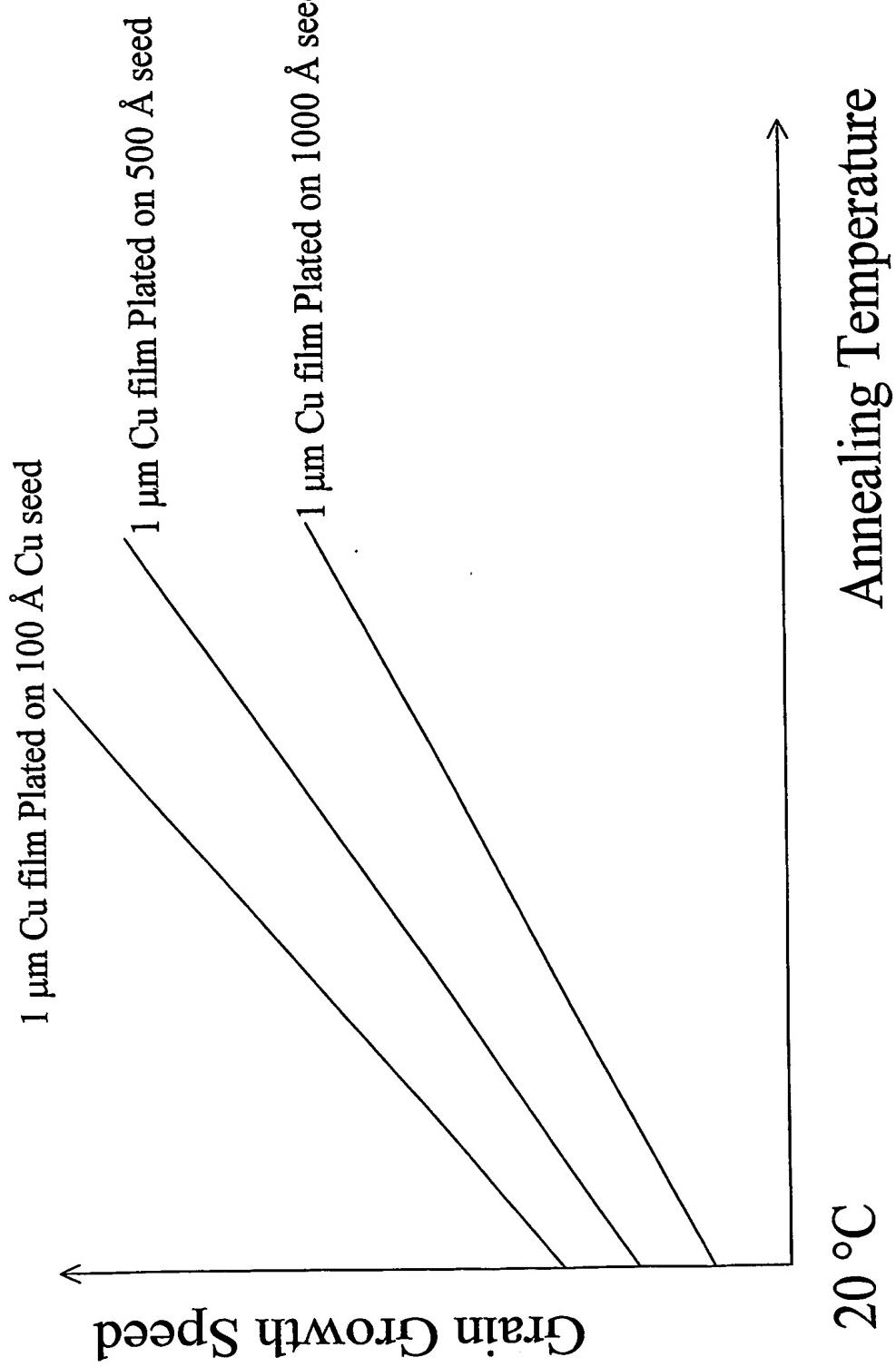


Fig. 27

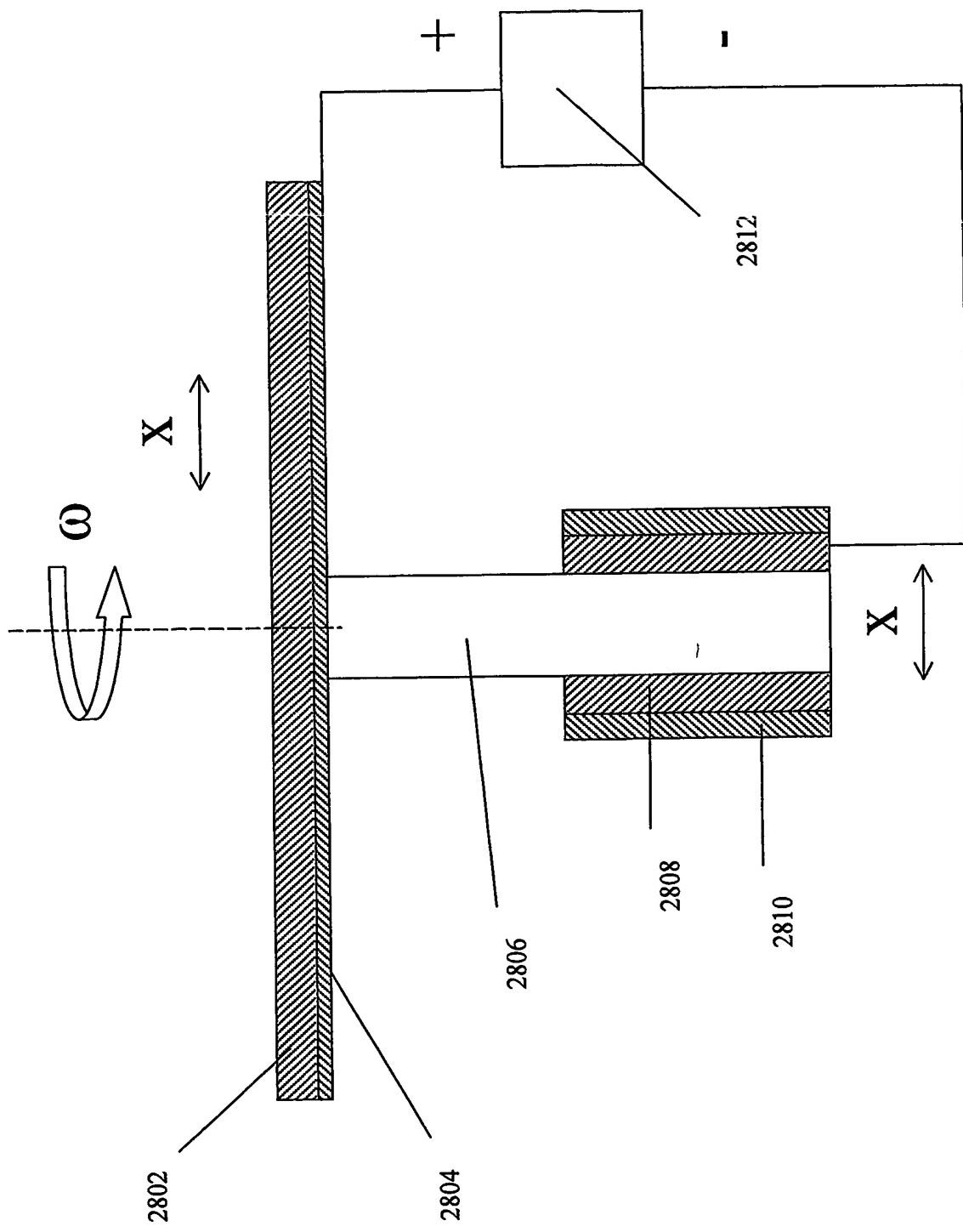


Fig. 28A

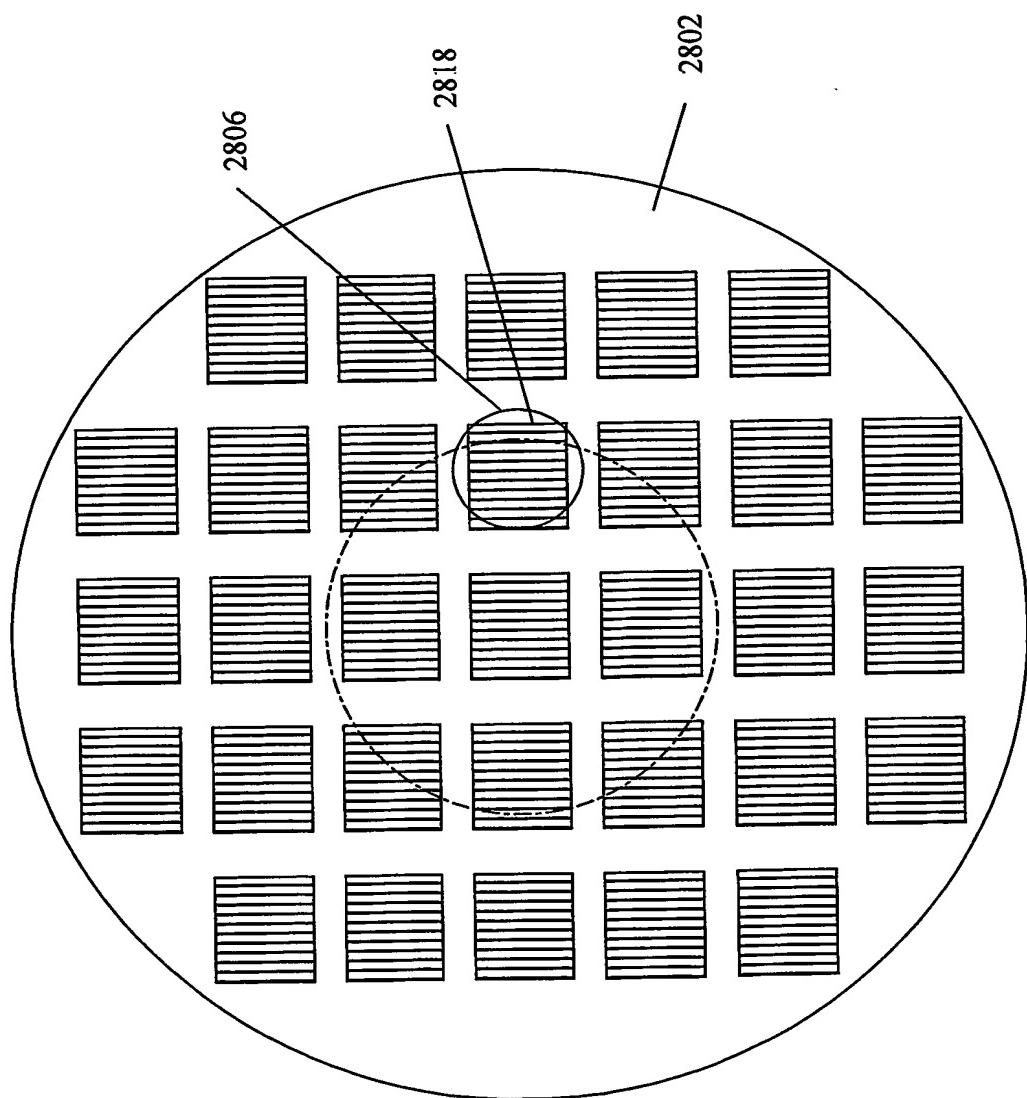


Fig. 28B

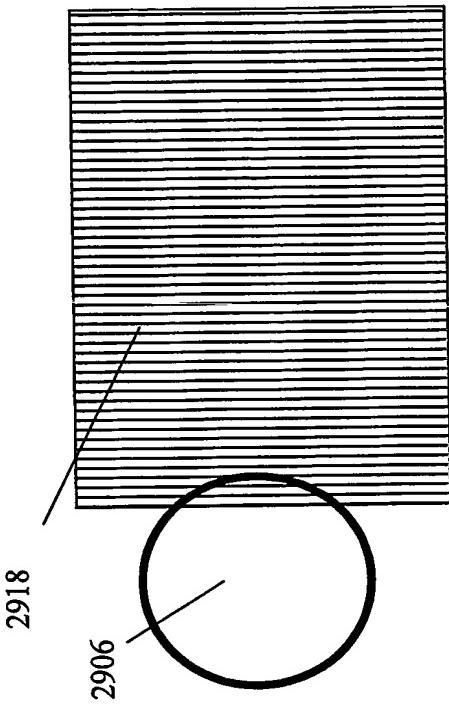


Fig. 29B

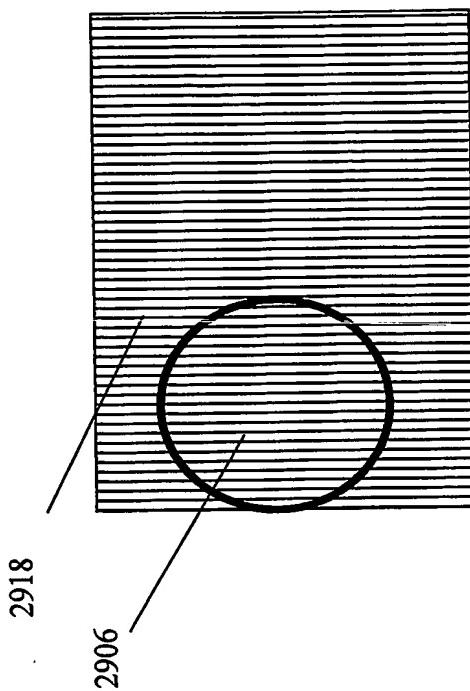


Fig. 29D

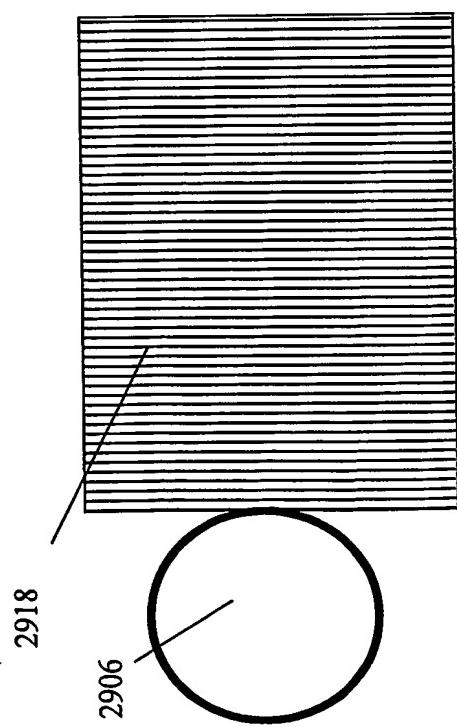


Fig. 29A

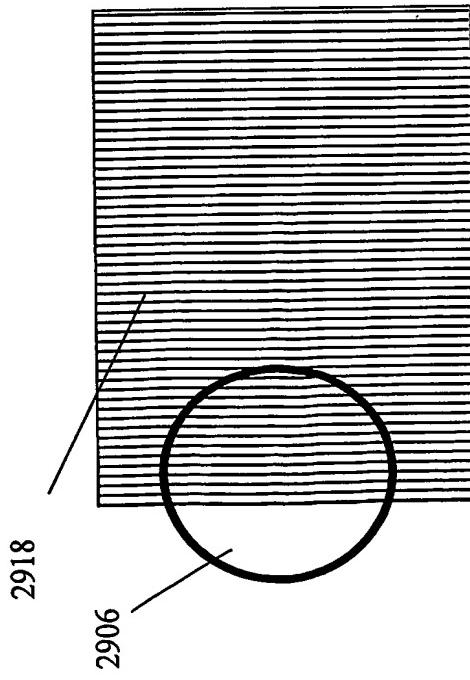


Fig. 29C

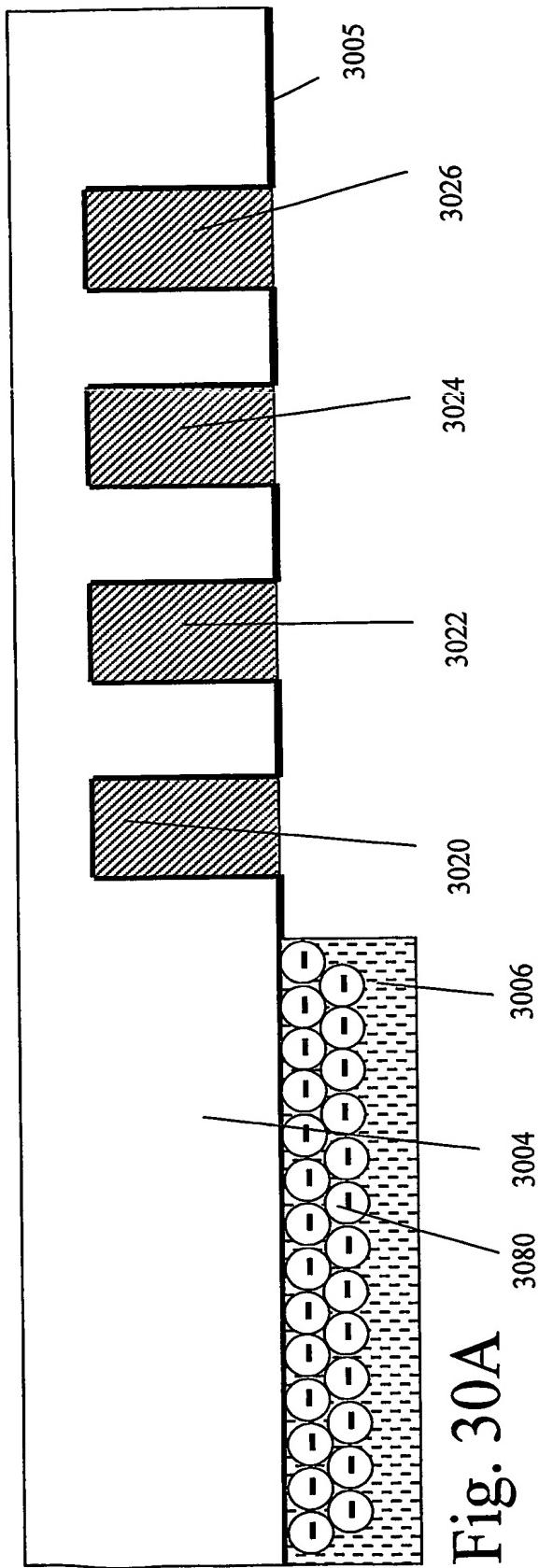


Fig. 30A

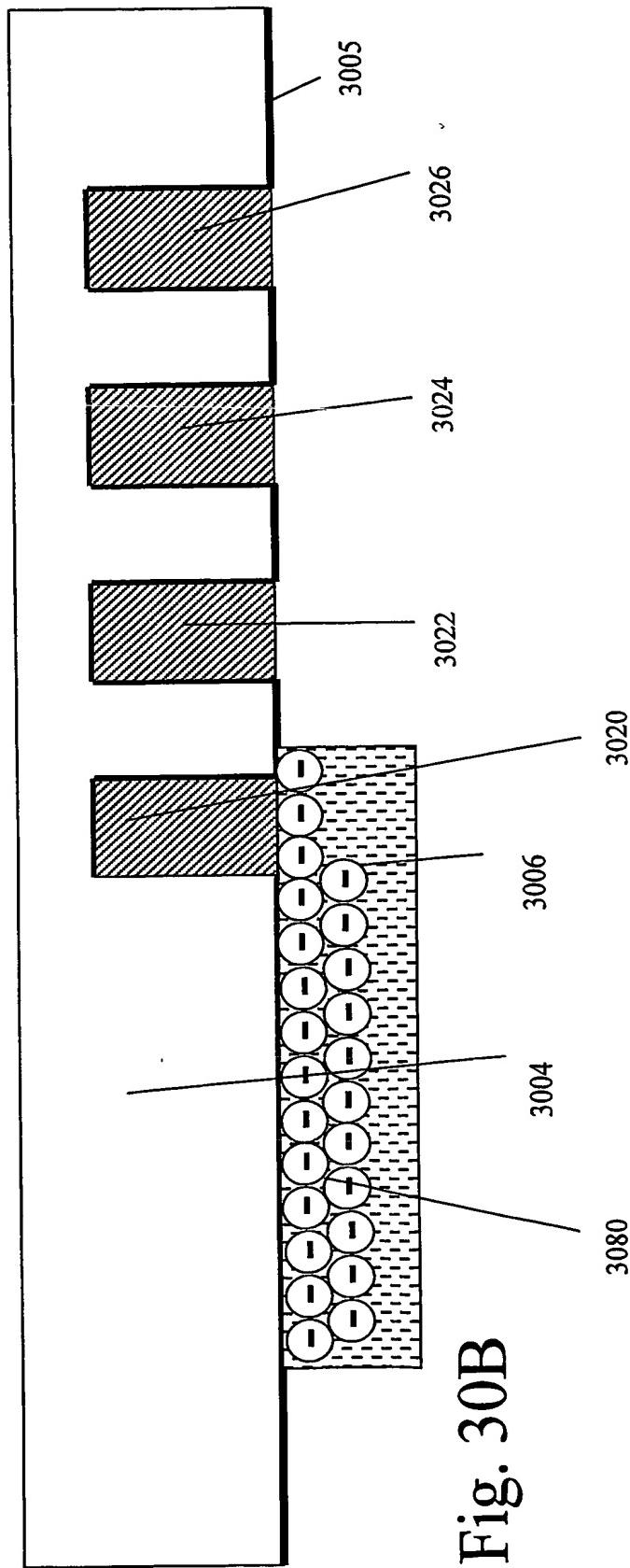


Fig. 30B

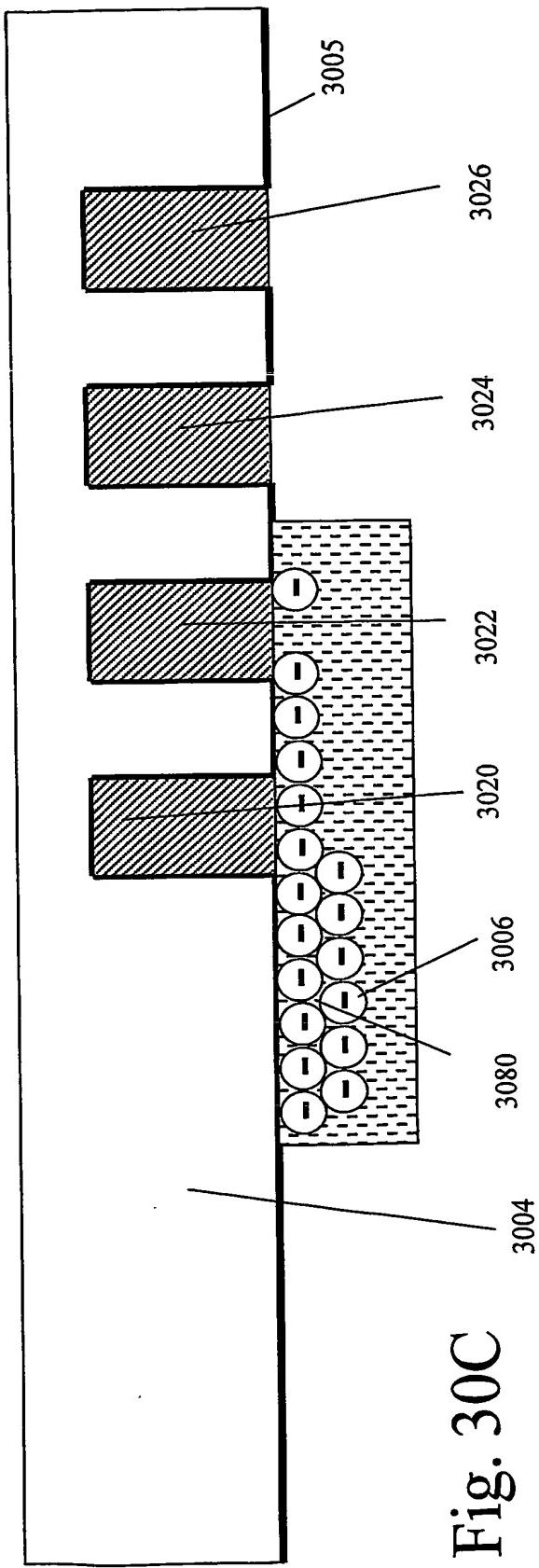


Fig. 30C

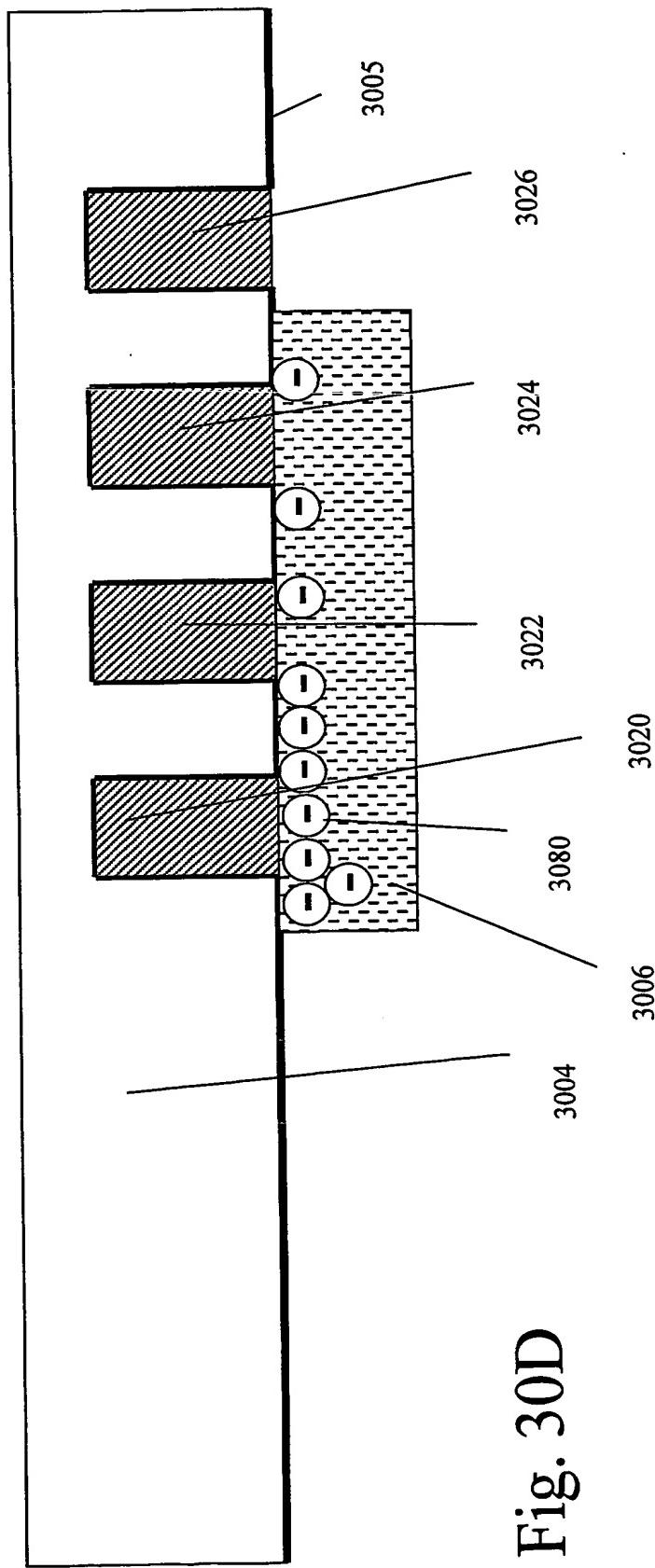


Fig. 30D

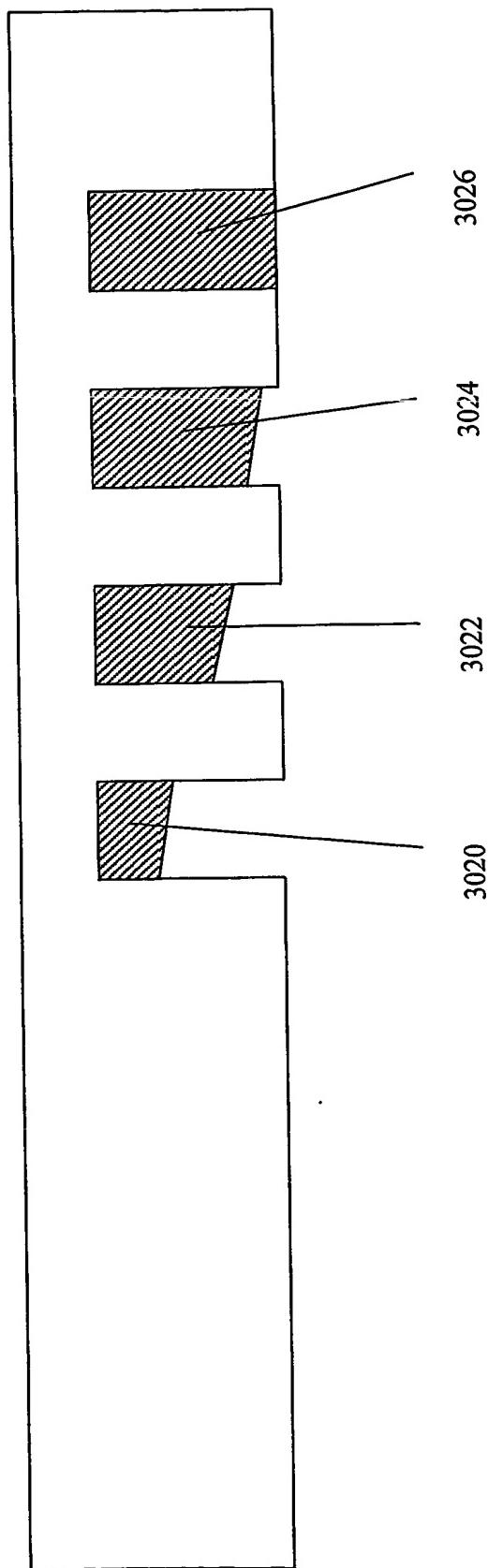


Fig. 30E

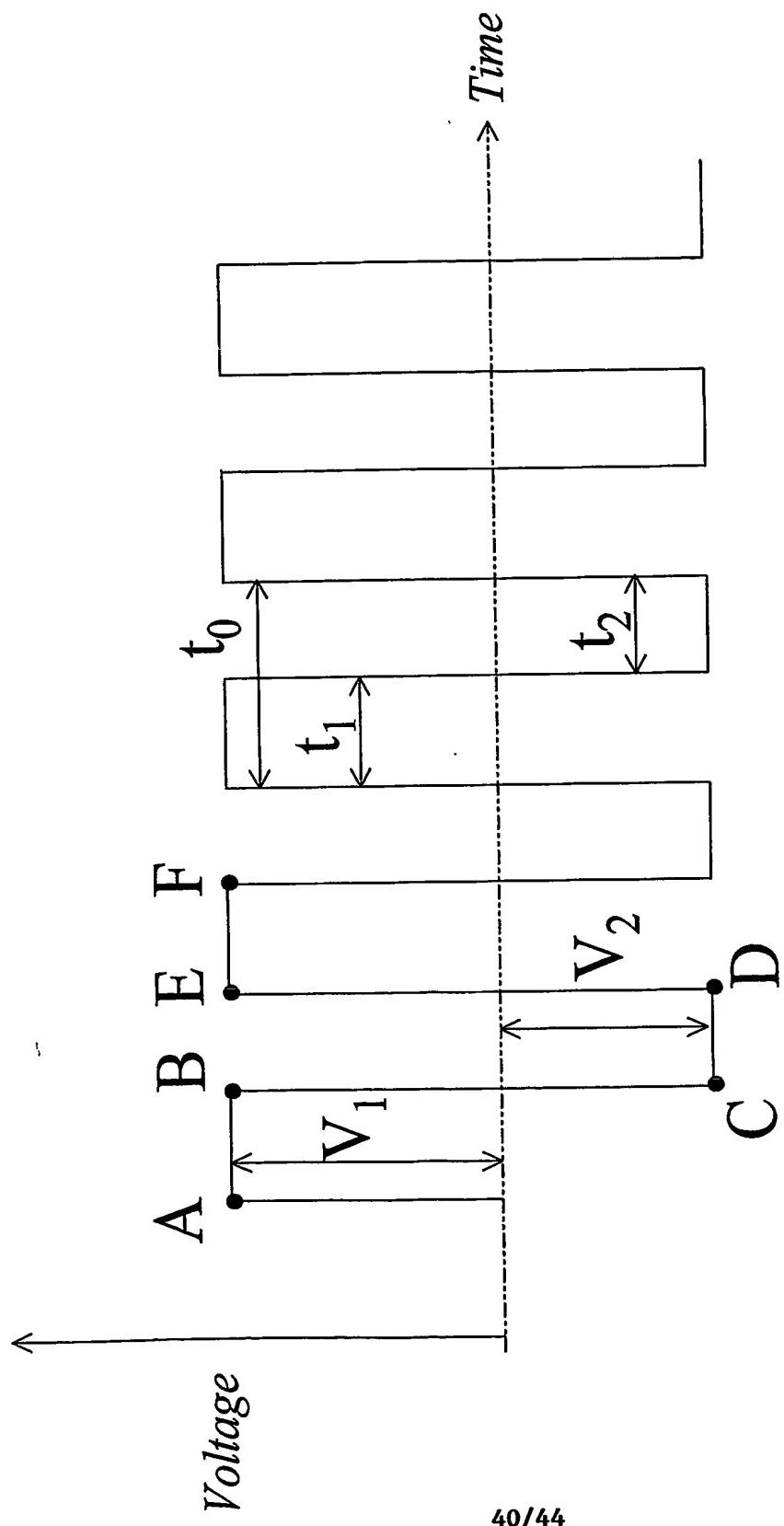


Fig. 31

Wave point "A"

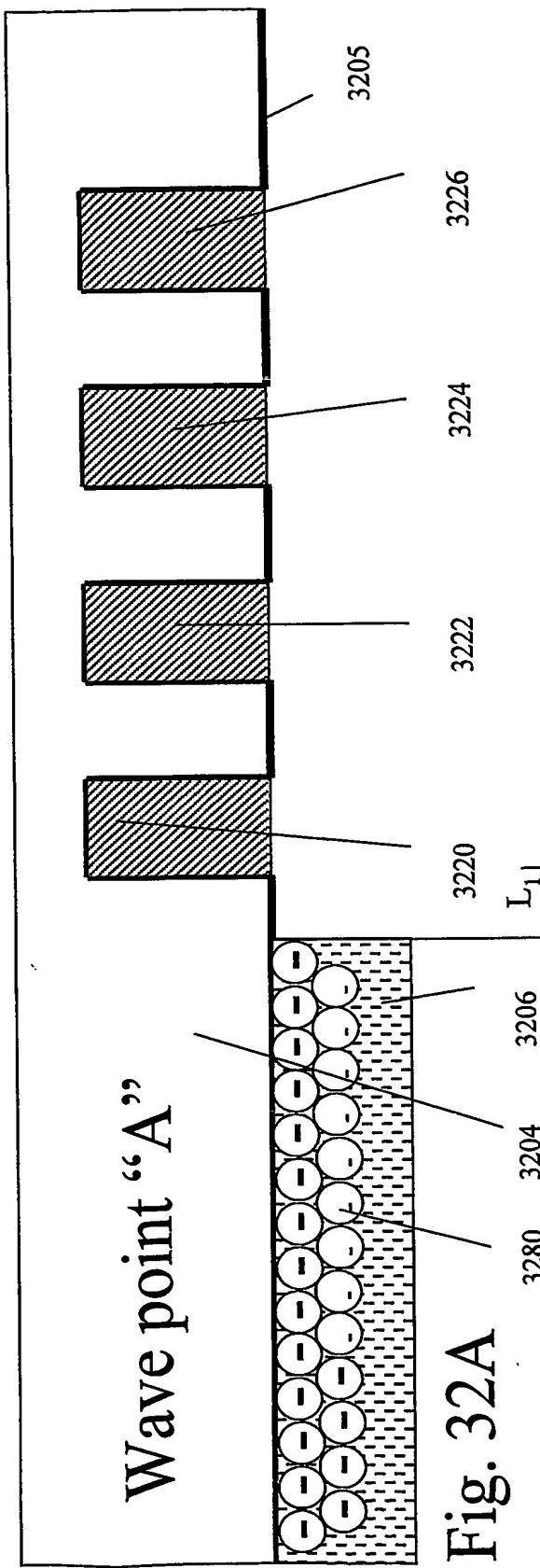


Fig. 32A

Wave point "B"

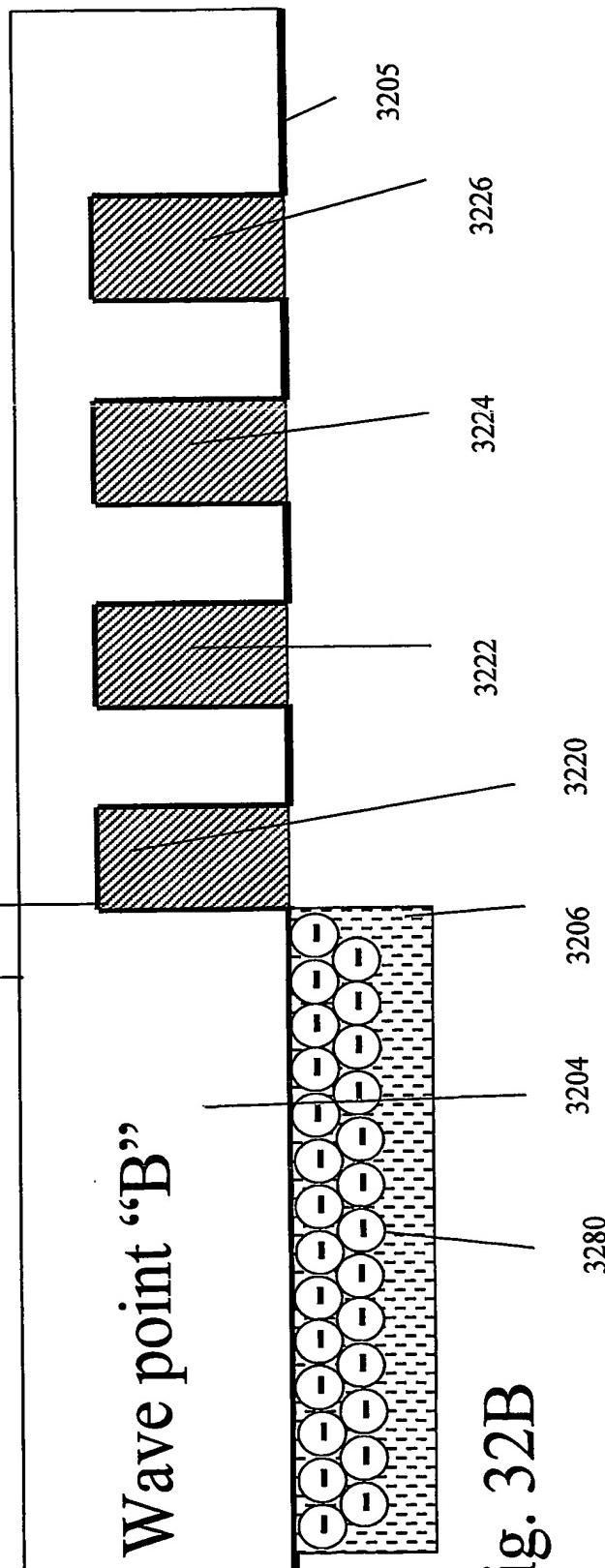


Fig. 32B

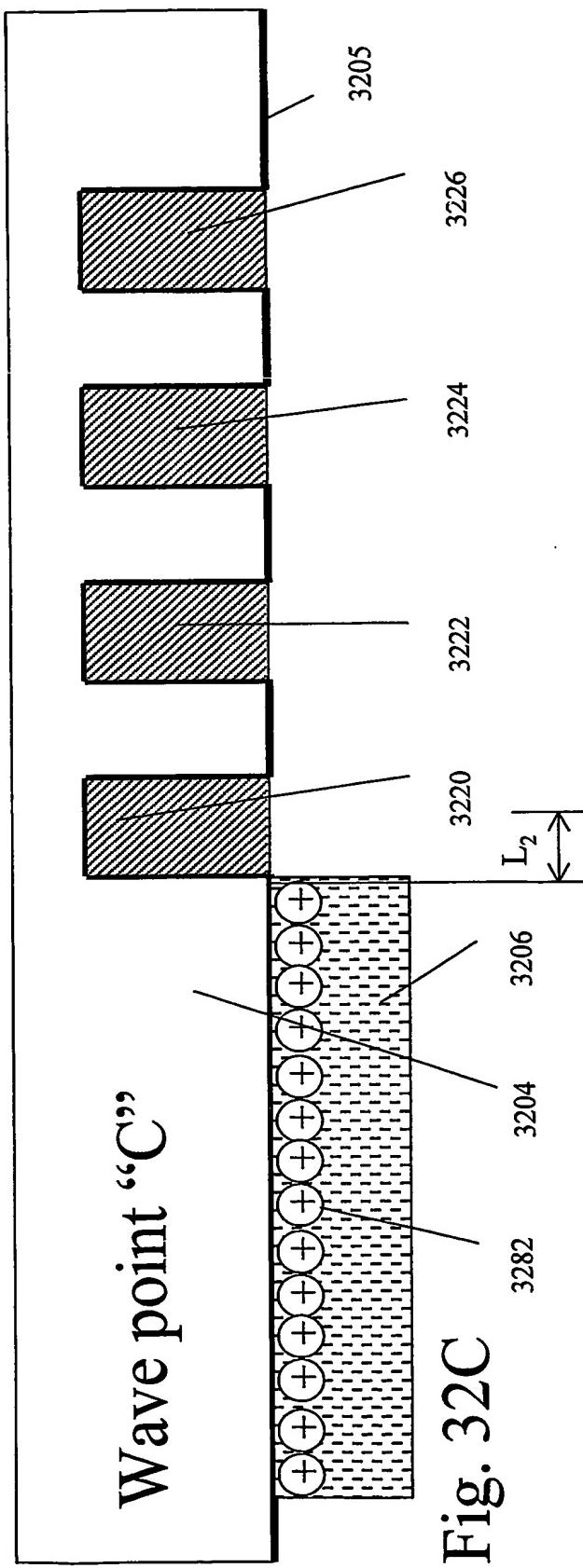


Fig. 32C

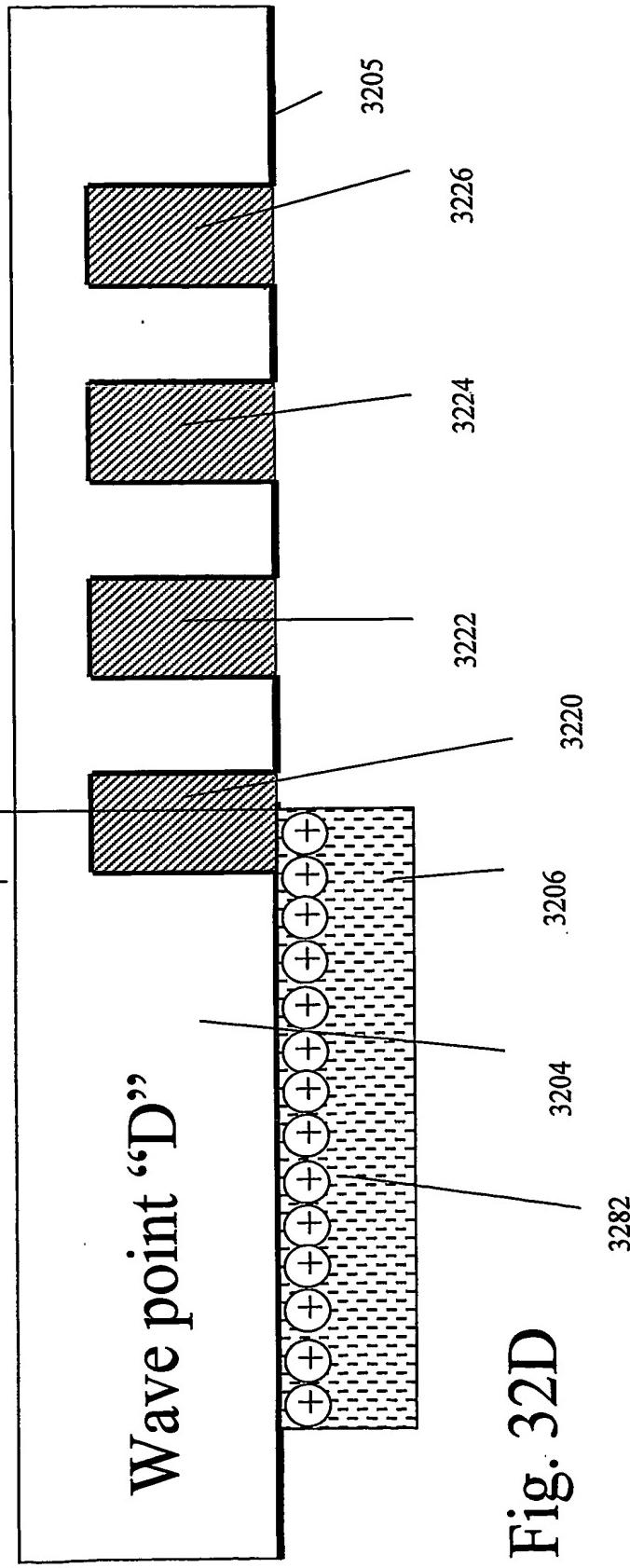


Fig. 32D

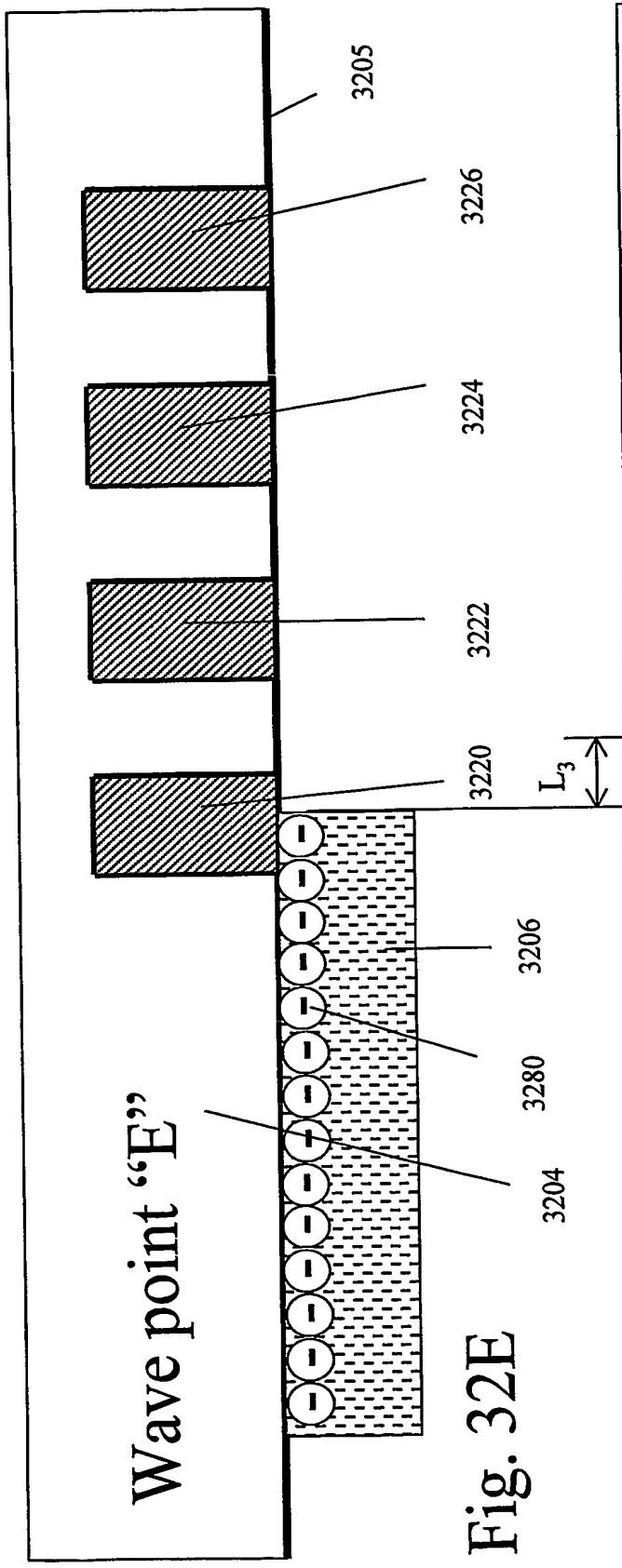


Fig. 32E

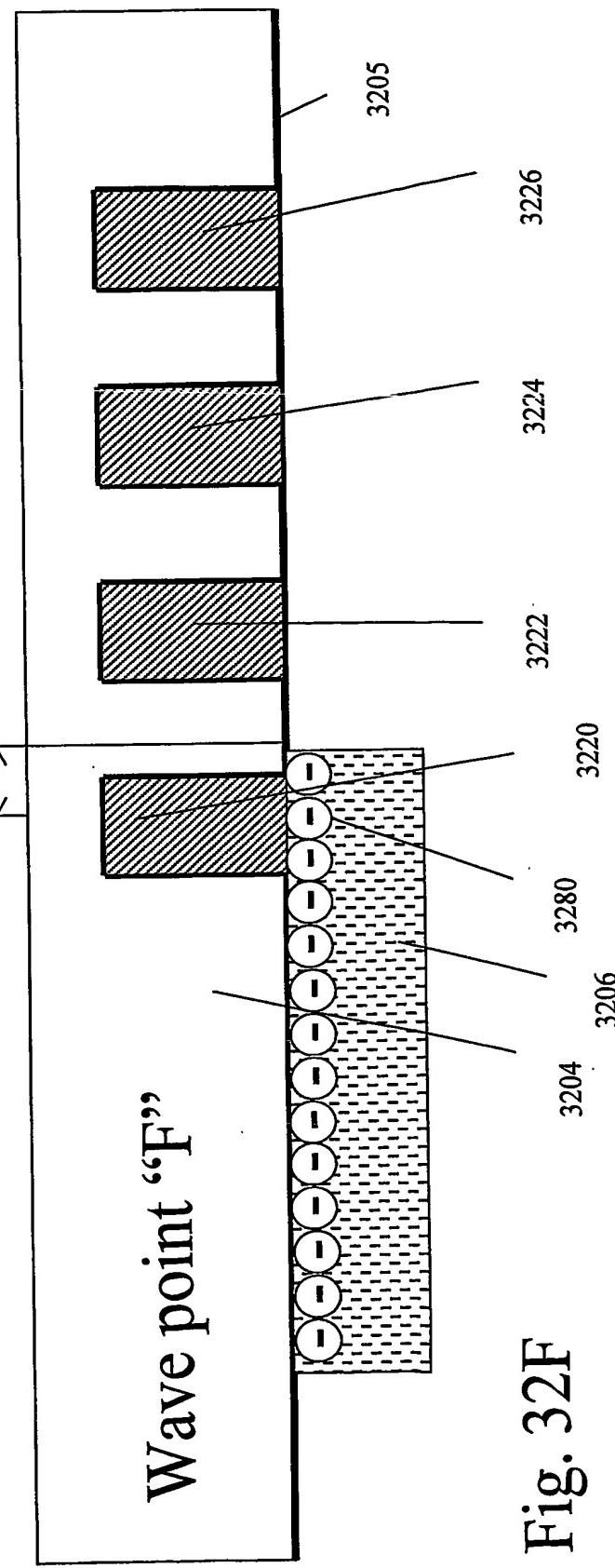


Fig. 32F

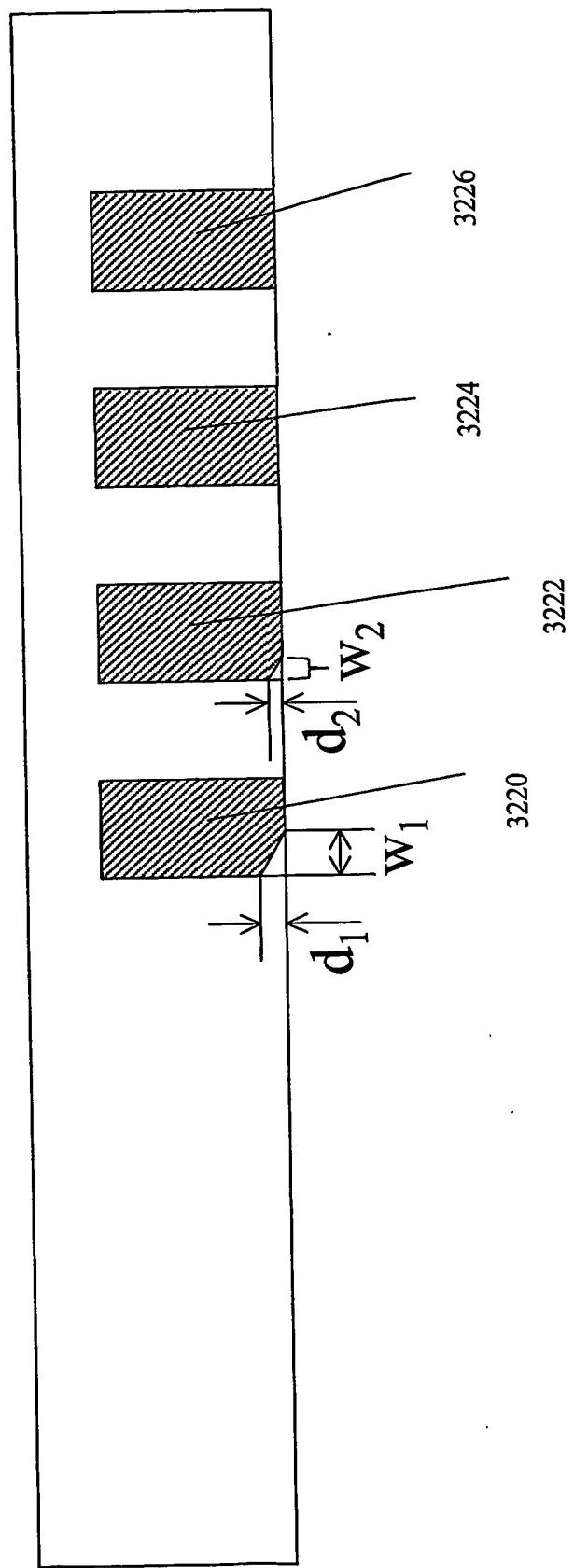


Fig. 32G